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ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS
GEOTECHNICAL LAB M E HYNES-GRIFFIN ET AL. JUL 84

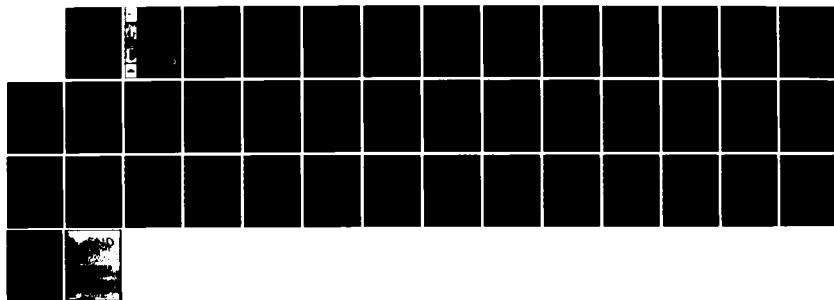
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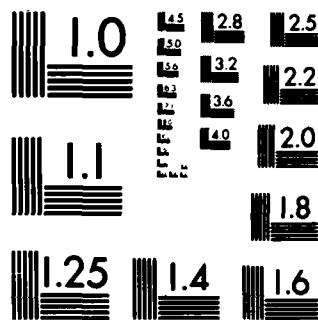
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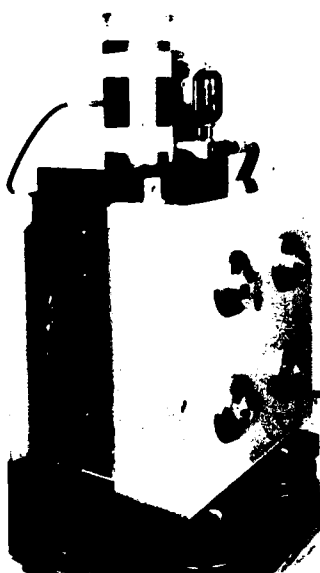




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RATIONALIZING THE SEISMIC COEFFICIENT METHOD

by

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July 1984

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20. ABSTRACT (Continued).

is the consideration of amplification of the base motions in the embankment, which is evaluated by means of a linear elastic analysis. Sliding block analyses have been done for 348 horizontal components of natural earthquakes and 6 synthetic records. These computations, together with available results of amplification analyses, suggest that a pseudostatic seismic coefficient analysis would be appropriate for embankment dams where it is not necessary to consider (a) liquefaction or severe loss of shear strength, (b) vulnerability of the dam to small displacements, or (c) very severe earthquakes, of magnitude 8 or greater. A factor of safety greater than 1.0, with a seismic coefficient equal to one-half the predicted bedrock acceleration, would assure that deformations would not be dangerously large.

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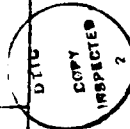
PREFACE

The screening analysis reported herein is based on seismic stability evaluations of several earth dams, in particular Richard B. Russell Dam in Georgia and South Carolina and Ririe Dam in Idaho, and was performed by the Earthquake Engineering and Geophysics Division (EE&GD), Geotechnical Laboratory (GL), U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss. This study was sponsored by the Office, Chief of Engineers (OCE), U. S. Army, under the Civil Works Investigational Studies (CWIS), Soils Research Program (Work Unit 31145), "Liquefaction of Dams and Foundations During Earthquakes," for which Mr. R. F. Davidson was the OCE Technical Monitor.

The research was conducted and the report prepared by Ms. M. E. Hynes-Griffin, EE&GD, and Dr. A. G. Franklin, Principal Investigator and Chief, EE&GD. Appendix A was prepared by Mr. F. K. Chang, EE&GD. The study was performed under the general supervision of Dr. W. F. Marcuson III, Chief, GL.

COL Tilford C. Creel, CE, was Commander and Director of WES during the preparation of this report. Mr. F. R. Brown was Technical Director.

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RATIONALIZING THE SEISMIC COEFFICIENT METHOD

PART I: INTRODUCTION

1. Until the 1960's, seismic analysis of dams consisted essentially of the seismic coefficient method, in which a static, horizontal inertia force was applied to the potential sliding mass in an otherwise conventional static limit analysis. The magnitude of the inertia force was chosen on the basis of judgment and tradition; a rational basis was lacking. Alternatives to this approach became available during the 1960's and 1970's. A method of analysis that dealt with the softening or liquefaction of granular soils was evolved, largely through work at the University of California at Berkeley, with Professor H. B. Seed playing the leading role. This approach is based on comparison of dynamic shear stresses computed in a transient response analysis to the cyclic strength (resistance to liquefaction) obtained from laboratory cyclic shear tests or from empirical correlations of liquefaction occurrence (and non-occurrence) with Standard Penetration Tests (Seed, et al. 1975a, b; Seed 1979; Seed and Idriss 1983). A second alternative is to deal with the permanent deformations that might be anticipated if the embankment and foundation soils do not suffer liquefaction or severe softening under cyclic loading, using as an idealized model of the displaced part of the embankment a rigid block sliding on an inclined plane. This approach was proposed by the late Professor N. M. Newmark in his Rankine Lecture (1965). Other contributions to a coherent procedure using this approach have been made by Professors Ambraseys and Sarma, Imperial College, London (e.g. Ambraseys and Sarma 1967; Sarma 1975, 1979), the Berkeley group (Goodman and Seed 1966, Makdisi and Seed 1977), and the U. S. Army Engineer Waterways Experiment Station (WES) (Franklin and Chang 1977, Franklin and Hynes-Griffin 1981).

2. Sufficient experience has been gained in the application of the Newmark approach to allow some conclusions to be drawn. In the absence of liquefaction effects, dams with adequate static factors of safety against sliding are not likely to be predicted by this analysis to be subject to deformations so large as to endanger their reservoirs, through limited sliding deformations may be predicted. This result suggests that many--perhaps most--permanent displacement analyses do not really need to be done, and that some simple screening method should be applied to separate those dams that are clearly

safe against earthquake-induced failure from those that require further analysis. A seismic coefficient analysis can serve this screening function, because the accumulated experience in permanent displacement analyses now provides a rational basis for choosing the value of the coefficient. The rationale is based on assuring that deformations will be limited to tolerable values, assuming the worst combination of earthquake loads and resonant embankment response. A procedure that uses this approach is proposed in this report.

PART II: PERMANENT DISPLACEMENT ANALYSIS

3. The major components of a permanent displacement analysis of the Newmark type, as applied by the WES, are shown in Figure 1. The primary component is the analysis of motions of a system consisting of a rigid block sliding on an inclined plane, chosen to represent a potential sliding mass in an embankment, as described by Newmark. A conventional limit analysis, or slope stability analysis, with slight modifications, provides the shearing resistance between the block and plane. Because bedrock motions may be amplified upon being propagated upward through an embankment, a rigid-body model may underestimate displacements, and an analysis of the amplification response of the embankment is incorporated to account for amplified accelerations in the embankment.

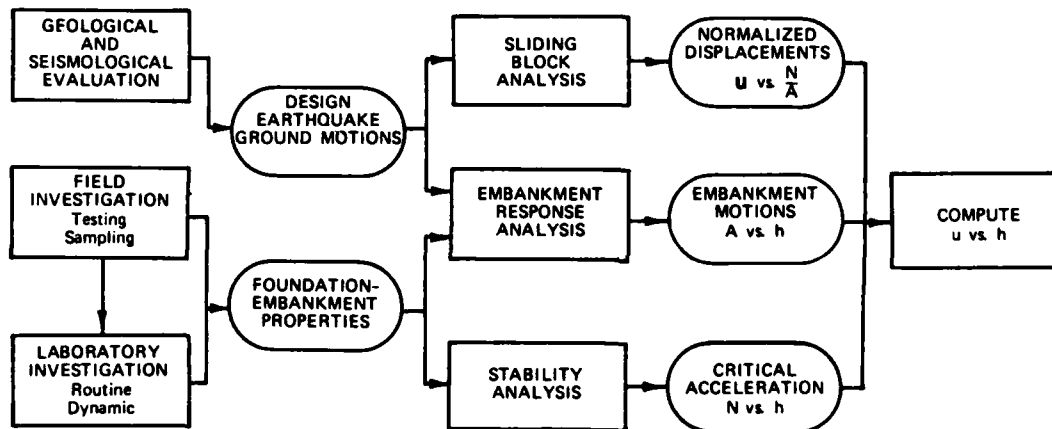


Figure 1. Permanent displacement analysis

Stability Analysis

4. The concept of the traditional pseudostatic, seismic coefficient method of analysis is illustrated in Figure 2. In an otherwise conventional static stability analysis, such as a method of slices analysis, the earthquake loading is represented by a statically applied horizontal force kW , where W is the weight of the slice and k is the seismic coefficient, which is some fraction of gravity. The value of k is generally prescribed by code or regulation, with values usually in the range of 0.05 to 0.20, depending on the seismicity of the site. The procedure is described in EM 1110-2-1902 (U. S. Army, Office, Chief of Engineers 1970) and in many standard texts.

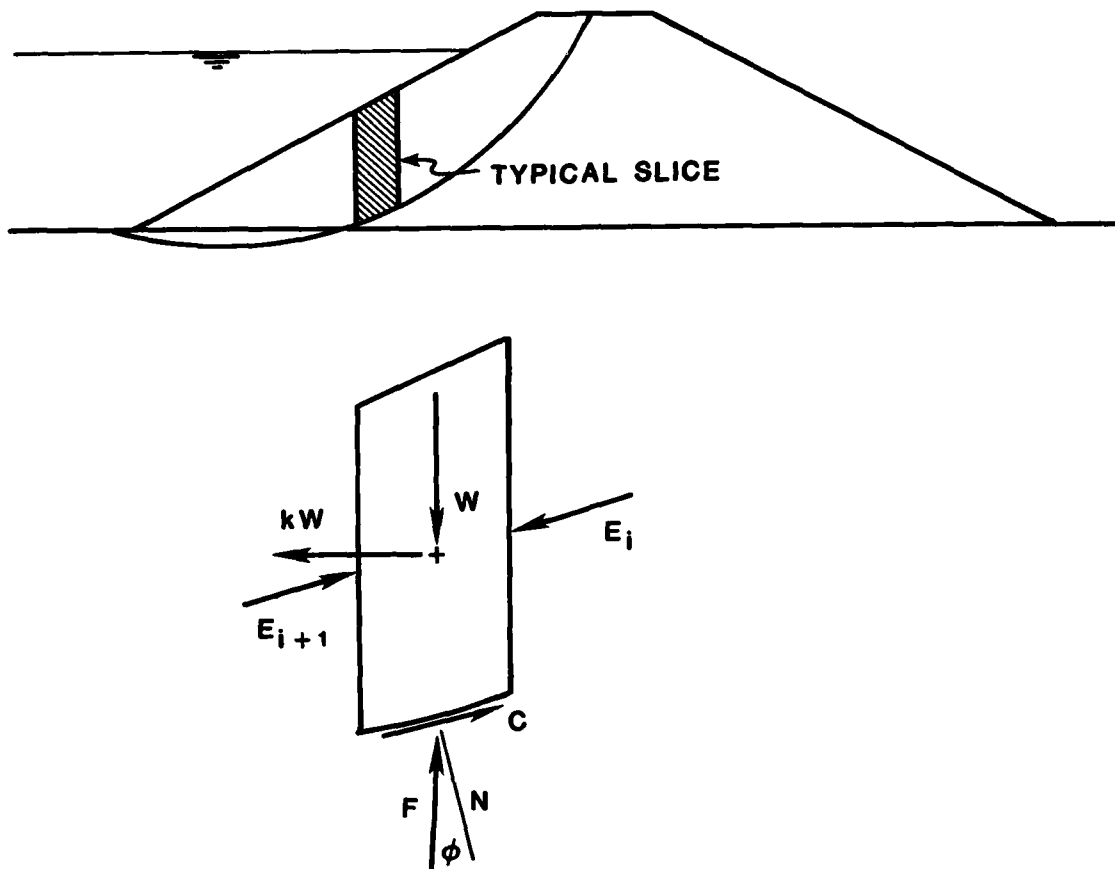


Figure 2. Earthquake stability analysis by pseudostatic method using seismic coefficient

5. For analysis of permanent displacements, the shearing resistance between the potential sliding mass and the underlying base is evaluated in terms of a critical acceleration N , defined as the acceleration (of the ground or embankment below the sliding surface) that will reduce the factor of safety against sliding to unity, i.e., that will make sliding imminent. The value of N , which is expressed as a fraction of gravity (g), is obtained through a stability analysis similar to conventional pseudostatic stability analyses, but which includes two special features. One is that the stability is evaluated in terms of a critical acceleration rather than a factor of safety, and the other is that, because the amplified accelerations vary over the height of the embankment, critical accelerations are determined for possible sliding masses whose bases lie at various elevations in the section (Figure 3).

6. The analysis may be performed using conventional stability analysis

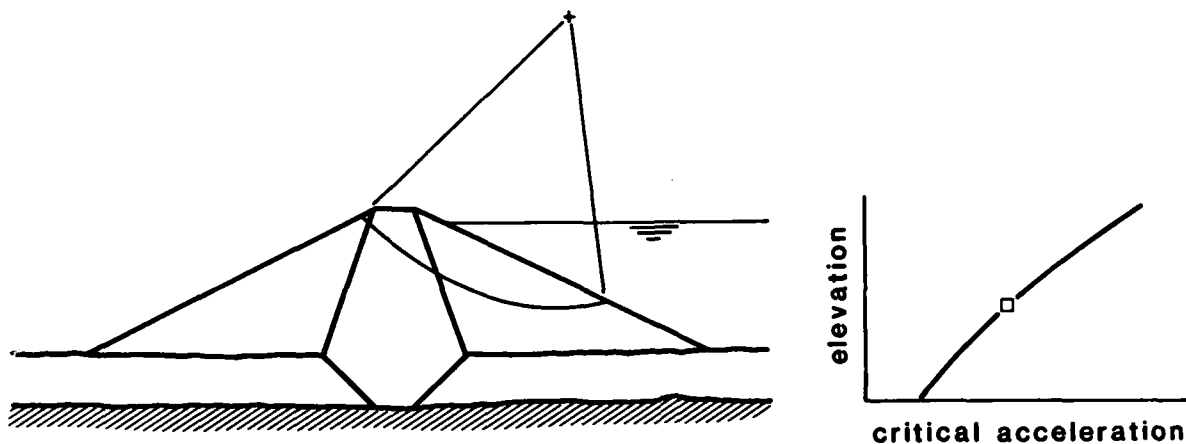


Figure 3. Critical acceleration as a function of elevation

methods such as those of Bishop (1955) or Morgenstern and Price (1965). Trial values of acceleration may be used to find the value that reduces the factor of safety to unity. The Sarma method (Sarma 1975), which employs a slip surface of arbitrary shape, determines the value of N directly.

7. In principle, the analysis can be performed on either a total or an effective stress basis, but the problems of estimating pore pressures induced by cyclic shearing are avoided by using a total stress analysis. The usual Corps of Engineers practice for static stability analyses is to use a composite shear strength envelope based on the S test (consolidated-drained) at low confining pressures and the R test (consolidated-undrained) at high confining pressures (Figure 4). This strength envelope, which conservatively takes into account possible dissipation of shear-induced negative pore pressures that might occur in the field but cannot occur in an undrained test in the laboratory, is recommended for pervious soils. For soils of low permeability, in which undrained conditions are more likely to exist during an earthquake, an undrained (R) strength envelope would be appropriate.

8. Makdisi and Seed (1977) point out that substantial permanent strains may be produced by cyclic loading of soils to stresses near the yield stress, while essentially elastic behavior is observed under many (>100) cycles of loading at 80 percent of the undrained strength. They recommend the use of 80 percent of the undrained strength as the "dynamic yield strength" for soils that exhibit small increases in pore pressure during cyclic loading, such as clayey materials, dry or partially saturated cohesionless soils, or very dense saturated cohesionless materials.

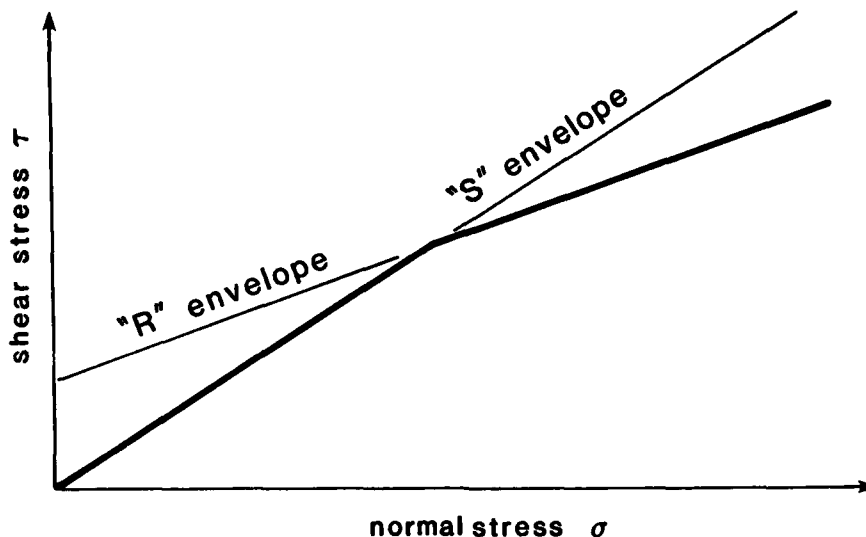
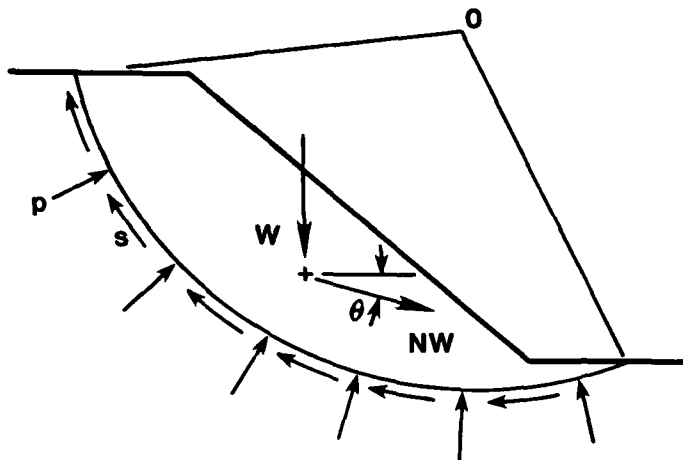


Figure 4. Composite "S-R" strength envelope

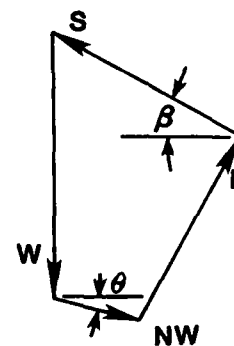
Sliding Block Analysis

9. Figure 5 presents the elements of the sliding block analysis (Franklin and Chang 1977). The potential sliding mass in Figure 5a is in a condition of impending failure, so that the factor of safety equals unity. This condition is caused by the acceleration of both the base and the mass toward the left of the sketch with an acceleration of Ng . The acceleration of the mass is limited to this value by the limit of the shear stresses that can be exerted across the contact, so that if the base acceleration were to increase, the mass would move downhill relative to the base. By D'Alembert's principle, the limiting acceleration is represented by an inertia force NW applied pseudostatically to the mass in a direction opposite to the acceleration.

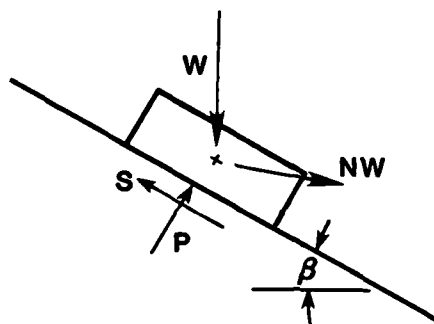
10. Figure 5b shows the force polygon for this situation. The angle of inclination θ of the inertia force may be found as the angle that is most critical; this is, the angle that minimizes N . Its value is usually within a few degrees of zero, and since the results of the analysis are not sensitive to it, it can generally be ignored. The angle β is the direction of the resultant S of the shear stresses on the interface and is determined in the course of the stability analysis. The same force polygon applies to the model of a sliding block on a plane inclined at an angle β to the horizontal (Figure 5c). Hence, the sliding block model is used to represent the sliding mass in an embankment.



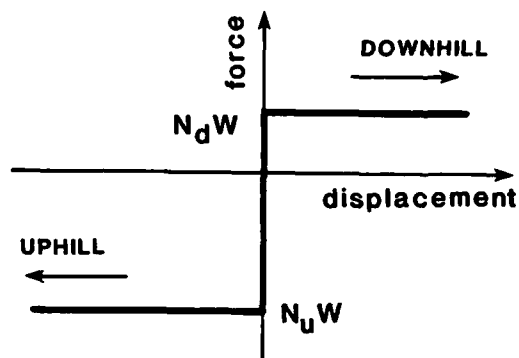
a. POTENTIAL SLIDING MASS



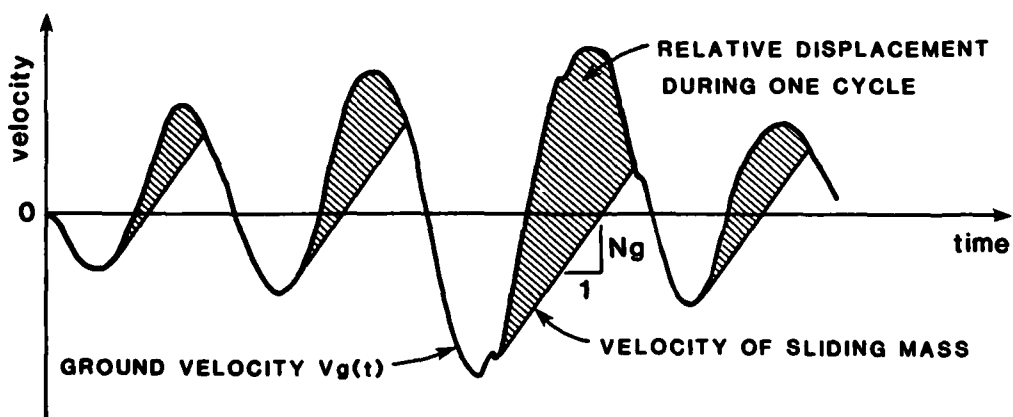
b. FORCE POLYGON FOR F.S.=1.0



c. SLIDING BLOCK MODEL



d. FORCE-DISPLACEMENT RELATION



e. COMPUTATION OF DISPLACEMENT

Figure 5. Elements of the sliding block analysis

11. The force-displacement relation in Figure 5d is assumed to apply to this system. The force in this diagram is the inertia force corresponding to the instantaneous acceleration of the block, and the displacement is the sliding displacement of the block relative to the base. It is usually assumed that resistance to uphill sliding is large enough that all displacements are downhill. This assumption, in addition to simplifying the calculations, is both realistic and conservative (Franklin and Chang 1977).

12. If the base (i.e., the inclined plane) is subjected to some sequence of acceleration pulses (the earthquake) large enough to induce sliding of the block, the result will be that after the motion has abated, the block will come to rest at some displaced position down the slope. The amount of permanent displacement, which will be called u , can be computed by using Newton's second law of motion, $F = ma$, to write the equation of motion for the sliding block relative to the base, and then numerically or graphically integrating (twice) to obtain the resultant displacement. During the time intervals when relative motion is occurring, the acceleration of the block relative to the base is given by

$$\begin{aligned}\ddot{u} = a_{rel} &= (a_{base} - N) \cdot \frac{\cos(\beta - \theta - \phi)}{\cos \phi} \\ &= (a_{base} - N) \cdot \alpha\end{aligned}\tag{1}$$

where

a_{rel} = relative acceleration between the block and the inclined plane

a_{base} = acceleration of the inclined plane, a function of time

N = critical acceleration level at which sliding begins

β = direction of the resultant shear force and displacement, and the inclination of the plane

θ = direction of the acceleration, measured from the horizontal

ϕ = friction angle between the block and the plane

The acceleration a_{base} is the earthquake acceleration acting at the level of the sliding mass in the embankment. It is assumed to be equal to the bedrock acceleration multiplied by an amplification factor that accounts for the quasi-elastic response of the embankment.

13. The permanent displacement is determined by twice integrating the relative accelerations over the total duration of the earthquake record. It is assumed that ϕ , β , and θ do not change with time; thus, the coefficient

α is a constant and is not involved in the integration. In the final stage of analysis, the result of the integration is multiplied by the coefficient α , the determination of which requires knowledge of the embankment properties and the results of the pseudostatic stability analysis. For most practical problems, the coefficient α differs from unity by less than 15 percent (Figure 6). For the purposes of this report, a value of unity will be assumed.

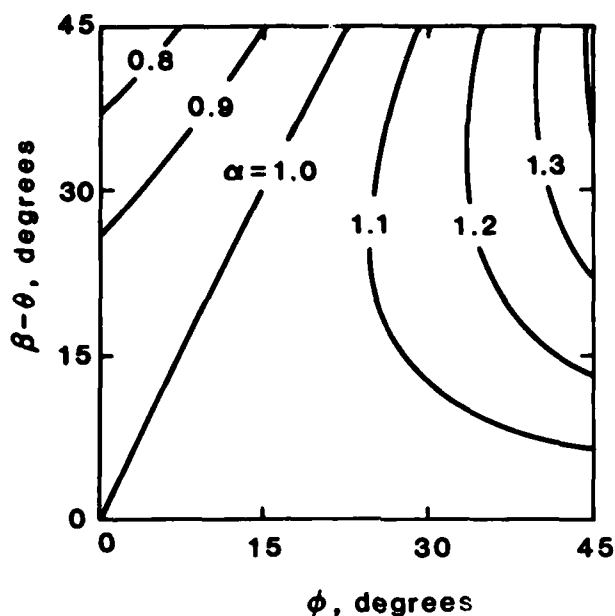


Figure 6. Values of the coefficient α

14. The integration can be easily visualized on a plot of base velocity versus time, obtained by a single integration of the acceleration record (Figure 5e). Since the slope of the velocity curve is the acceleration, the limiting acceleration N_g of the block defines the velocity curve for the block by straight lines in those parts of the plot where the critical acceleration has been exceeded in the base. The area between the curves gives the relative displacement.

15. In this analysis, the characteristics of the sliding mass in the embankment are represented only by the critical acceleration N and the amplification factor, the latter being simply a constant multiplying factor. The permanent displacement u for a particular earthquake record can be determined as a function of N/A , where A_g is the peak value of the earthquake acceleration, and the u versus N/A curve can be determined from the earthquake record without reference to a particular embankment.

16. Kutter (1982) has done limited experimental testing of this method by means of model embankments shaken by simulated earthquakes in the Cambridge University geotechnical centrifuge. For these tests, the sliding block model gave poor predictions of very small displacements (<1 cm), but if strength degradation was provided for, it produced good predictions when the displacements at prototype scale were greater than about 1 cm.

17. The following example, drawn from Kutter's test results for embankment model D and earthquake I, demonstrates the application of the displacement calculation procedures described herein. If the yield acceleration for the embankment model is calculated on the basis of 80 percent of the measured shear strength, and the measured amplification of the base motion is included, the predicted displacement is 15.0 cm and the corresponding measured displacement is 16.4 cm at the prototype scale.

18. Sliding block analyses have been done at the WES for 348 horizontal earthquake components and 6 synthetic records. These calculations are tabulated in Appendix A. The results are summarized in Figure 7, which shows the mean, mean plus one standard deviation (σ), and upper bound curves, for all natural records and all synthetic records representing magnitudes smaller than 8.0. (Caution is recommended in interpreting these curves quantitatively in terms of relative probability, because the data base is biased by overrepresentation of a single earthquake, the 1971 San Fernando earthquake, which produced records at many locations.)

19. The question of how much deformation is tolerable has no single answer; it depends on such factors as the size and geometry of the dam, the zonation, the location of the sliding surface, and the amount of freeboard available. The authors have arbitrarily chosen 1 m of permanent displacement as a tolerable upper limit. Such a deformation would surely be considered serious damage, but it could be tolerated in most dams without immediately threatening the integrity of the reservoir. The unusual cases where a dam could not tolerate 1 m of displacement, because of small freeboard or vulnerability of critical design features to small displacements, should be evaluated by other methods.

20. When Figure 7 is entered at 100 cm (1 m) of displacement, the corresponding N/A value is 0.17. Thus, deformations will be limited to less than 1 m of displacement if the critical acceleration is as much as 0.17 times the peak acceleration on the sliding surface.

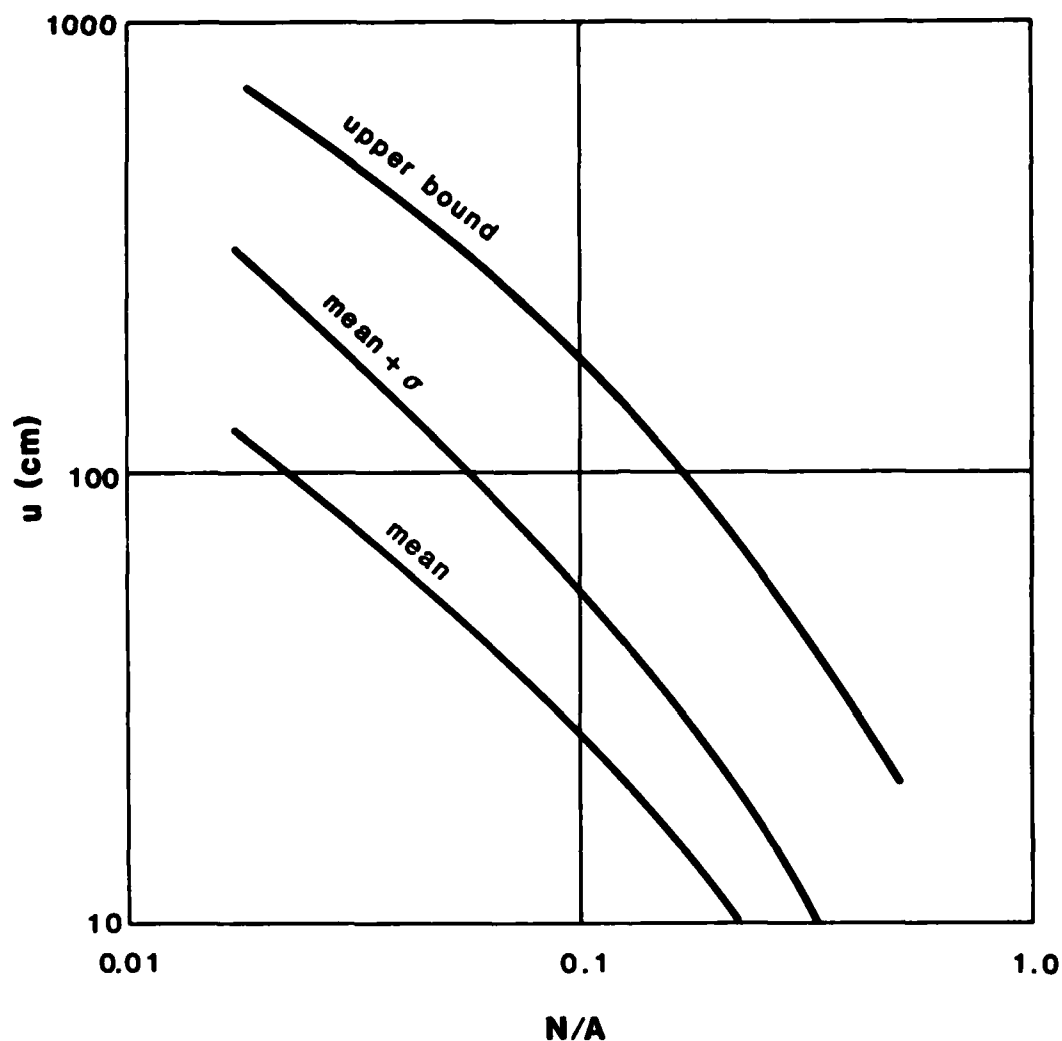


Figure 7. Permanent displacement u versus N/A , based on 348 horizontal components and 6 synthetic accelerograms

Embankment Response Analysis

21. Amplification of ground motions in the embankments may be examined by analysis of a shear-beam model of the embankment-foundation system. A closed-form solution has been obtained by Sarma (1979) for the problem illustrated by Figure 8. The model considered is an untruncated triangular wedge of height h_1 with a shear-wave velocity S_1 and density ρ_1 , underlain by a foundation layer with thickness h_2 , shear-wave velocity S_2 , and density ρ_2 . Both the wedge and foundation are linearly visco-elastic and have the same damping ratio D . The earthquake motions are considered to be rigid-body

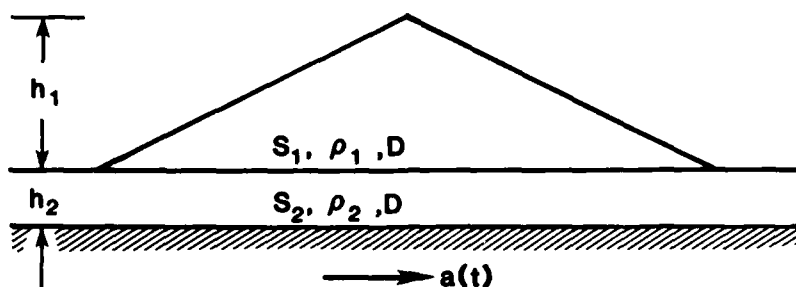


Figure 8. Mathematical model for viscoelastic shear beam analysis of embankment and foundation response by the Sarma method

motions in the rock underlying the foundation layer, and it is assumed that all motions are horizontal (hence, a shear-beam model). Shear-wave velocities and damping values are chosen so as to be consistent with expected strain levels. The computation of accelerations is carried out in the time domain.

22. Geometry and material properties are described in terms of the dimensionless parameters m and q , which are defined as

$$m = \frac{\rho_1 S_1}{\rho_2 S_2} \quad \text{and} \quad q = \frac{S_1 h_2}{S_2 h_1} \quad (2)$$

23. For use with the sliding block analysis, accelerations are averaged over a wedge that is selected to be approximately equivalent in volume and location to a potential sliding mass with its base at some chosen elevation, as shown in Figure 9. The average acceleration acting on the wedge at any instant is taken as

$$a_{av} = \frac{\int_A a(z) dA}{A} \quad (3)$$

where $a(z)$ is the acceleration of the area element dA , at elevation z , and A is the total area of the wedge.

24. The largest average acceleration that acts on the wedge at any time during the earthquake shaking is produced as the output of the computer program, and the ratio of that acceleration value to the peak bedrock acceleration is taken as the amplification factor for the wedge. In Figure 10, values of the amplification factor are plotted against the embankment fundamental period T_0 for one record of the Parkfield earthquake of 27 June 1966. Curves

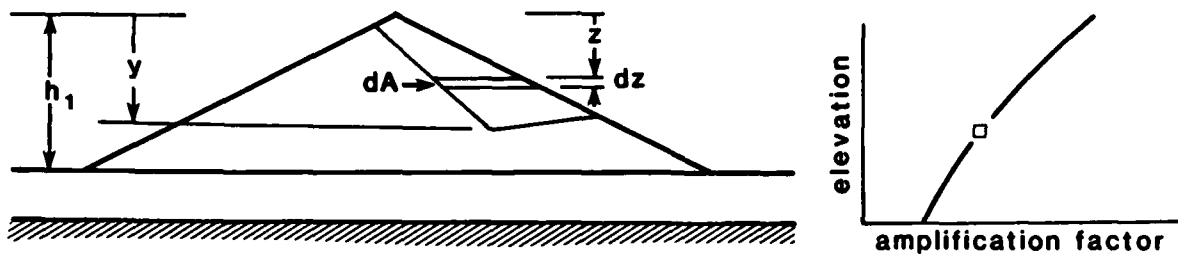


Figure 9. Computation of average acceleration acting on the sliding mass

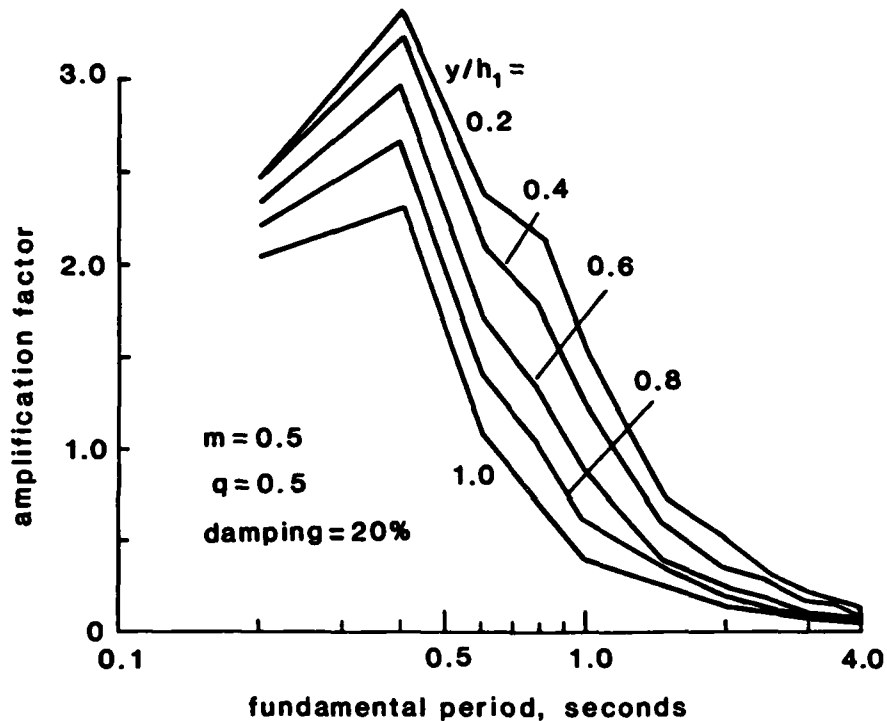


Figure 10. Amplification curves for the S 25 W component, Temblor No. 2 Record, Parkfield earthquake of 27 June 1966 (damping = 20 percent)

are shown for wedges with their bases at various distances y/h_1 (defined in Figure 9) from the crest, for a single combination of m and q values ($m = 0.5$, $q = 0.5$).

25. Amplification curves have been obtained from 27 strong-motion earthquake records and a wide range of m and q values (representing embankments on rock and on foundation layers of varied thickness, and with a variety of relative embankment-foundation stiffnesses). Damping values used ranged from 15 to 20 percent. Also, numerous computed amplification values have been obtained from finite element analyses and from the literature.

Figure 11 presents a summary of computed resonant response, obtained by plotting the values at the peaks of the amplification curves. Table 1 shows these peak amplification values. Amplification values obtained from finite element analyses, which do not necessarily represent resonant conditions, are generally lower than these curves indicate.

26. To use these curves in a permanent displacement analysis, pick off the amplification factor for the depth of sliding being investigated, and multiply the peak bedrock acceleration by that value before entering the plot of displacement versus N/A . This step involves an assumption that the sliding block analysis and the amplification analysis can be decoupled. In fact, there is good reason to believe that decoupling results in overestimates of the amplification when very strong shaking is involved. The amplification may be large in cases where the motions are small and the embankment behavior is nearly elastic (Gazetas, et al. 1981), but this assumption is not compatible with inelastic embankment response. If accelerations are high enough to produce sliding on a deep surface, then the embankment is incapable of propagating these large accelerations to higher elevations. The critical acceleration on a slip surface defines the magnitude of acceleration that can be propagated beyond it. At the same time, the critical acceleration always decreases with depth, in a homogeneous section with constant slopes.

27. A note of caution is in order for dams with abrupt changes in section or zoning that would cause a reduction in yield accelerations for slip surfaces above the base of the embankment. For example, some dams have slopes that steepen abruptly near the crest. However, for upstream slip surfaces, the reduction in yield acceleration due to steeper slopes is usually more than offset by an increase due to lower pore pressures if the steeper section lies above the pool elevation. Upstream or downstream berms will also result in relatively reduced yield accelerations for slip surfaces that lie entirely above the berms. For these or similar cases, a profile of yield accelerations can be developed from stability analyses; Figure 11 can be used to estimate amplification factors; and potential displacement can be calculated from Figure 7 for each of the potential slip surfaces identified in the stability analyses.

28. The authors conclude that, except for a few special cases, deep sliding surfaces are of greatest significance when evaluating the possibility of displacements that could threaten the integrity of the structure, and

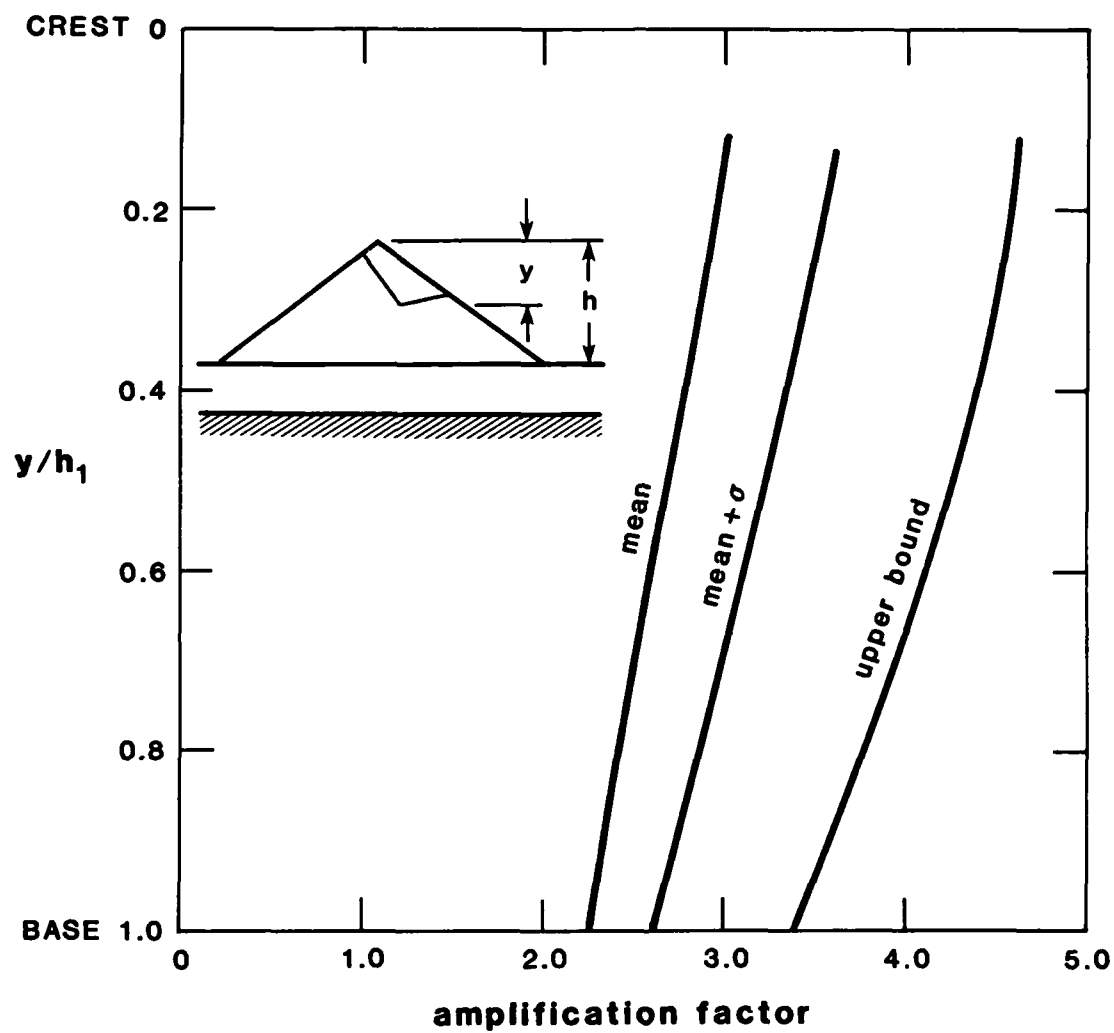


Figure 11. Amplification factors for linearly viscoelastic embankments at resonance

accordingly, they look for a limiting amplification factor representing sliding surfaces at the base of the embankment. Figure 11 shows that the value at the mean plus 2σ limit is approximately 3.0. Applying this amplification factor to the N/A value, 0.17, which gives an upper bound of 1-m displacement for the rigid-plastic sliding block, the ratio of critical acceleration to peak bedrock acceleration is 0.5.

PART III: CONCLUSIONS

29. The results of analysis of earthquake strong-motion records using a sliding block model and a decoupled elastic response analysis show that permanent displacements for deep-seated sliding surfaces limited to less than 1 m can be assured if the ratio of critical acceleration to peak bedrock acceleration is at least 0.5. This value is considered to be very conservative and subject to downward revision as better understanding of elastic-plastic amplification response of embankments is developed.

30. Furthermore, a pseudostatic, seismic coefficient analysis can serve as a useful screening procedure to separate dams that are clearly safe against earthquake-induced sliding failure from those that require further analysis. The permanent displacement analyses described in this report provide a rational basis for choosing the value of the seismic coefficient.

31. The suggested procedure is as follows:

- a. Carry out a conventional pseudostatic stability analysis, using a seismic coefficient equal to one-half the predicted peak bedrock acceleration.
- b. Use a composite S-R strength envelope for pervious soils, and the R (undrained) strength for clays, multiplying the shear strength in either case by 0.8.
- c. Use a minimum factor of safety of 1.0.

32. This procedure should not be used in the following cases:

- a. Where areas are subject to great earthquakes (of magnitude 8.0 or greater).
- b. Where materials in either the embankment or foundation are susceptible to liquefaction under the design cyclic loading.
- c. Where the available freeboard is small, or where the dam has safety-related features that are vulnerable to small deformations.

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Table 1
Amplification Factors for Embankment Response at Resonance Amplification Factor

m	q	$\frac{y}{h_1}$										$\frac{y - h_1 + h_2}{h_2}$				Damping Percent	Accelerogram
		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	1.2	1.4	1.6	1.8		
0	0	2.68	2.50	2.31	2.06	1.77	--	--	--	--	--	--	--	--	--	20	<div></div>
0.5	0.125	2.89	2.58	2.41	2.18	1.63	1.56	--	--	--	--	--	--	--	--		
0.5	0.25	3.34	2.92	2.55	2.35	2.10	1.64	1.56	1.44	--	--	--	--	--	--		
0.5	0.375	3.50	3.16	2.77	2.54	2.29	2.03	1.80	1.61	1.49	--	--	--	--	--		
0.5	0.5	3.47	3.20	2.88	2.66	2.44	2.20	1.99	1.80	1.61	1.51	--	--	--	--		
0.5	0.75	3.15	2.98	2.81	2.65	2.51	2.33	2.17	2.03	1.92	1.79	--	--	--	--		
0.5	1.00	2.78	2.71	2.64	2.57	2.49	2.37	2.26	2.15	2.07	1.98	--	--	--	--		
1.00	0.25	2.66	2.55	2.43	2.26	2.07	1.85	1.78	--	--	--	--	--	--	--		
1.00	0.50	2.54	2.49	2.41	2.32	2.17	2.02	1.85	1.75	--	--	--	--	--	--		
1.00	0.75	2.46	2.44	2.39	2.32	2.22	2.11	1.98	1.84	1.71	--	--	--	--	--		
1.00	1.00	2.42	2.40	2.36	2.31	2.23	2.15	2.06	1.94	1.83	1.70	--	--	--	--		
1.00	1.50	2.37	2.36	2.33	2.31	2.26	2.20	2.14	2.07	1.99	1.92	--	--	--	--		
1.00	2.00	2.36	2.35	2.33	2.30	2.27	2.24	2.19	2.13	2.08	2.03	--	--	--	--		
0.8	0.8	2.57	2.53	2.47	2.40	2.30	2.18	2.07	1.93	1.79	1.66	--	--	--	--		
0	0	2.58	2.29	1.89	1.66	1.43	--	--	--	--	--	--	--	--	--		
0.5	0.185	3.16	2.65	2.19	1.82	1.62	--	--	--	--	--	--	--	--	--		
0.5	0.5	2.98	2.77	2.41	2.23	1.95	--	--	--	--	--	--	--	--	--		
0	0	2.98	2.70	2.62	1.91	1.57	--	--	--	--	--	--	--	--	--		
0.5	0.185	3.34	3.04	2.58	2.19	1.79	--	--	--	--	--	--	--	--	--		
0.5	0.5	3.38	3.23	2.97	2.66	2.31	--	--	--	--	--	--	--	--	--		
0	0	2.55	2.44	2.25	2.01	1.71	--	--	--	--	--	--	--	--	--		
0.5	0.185	2.68	2.56	2.41	2.20	1.95	--	--	--	--	--	--	--	--	--		
0.5	0.5	2.69	2.67	2.61	2.51	2.35	--	--	--	--	--	--	--	--	--		
0	0	2.31	2.04	1.96	1.82	1.63	--	--	--	--	--	--	--	--	--		
0.5	0.185	2.66	2.31	2.07	1.95	1.78	--	--	--	--	--	--	--	--	--		
0.5	0.5	2.61	2.44	--	--	--	--	--	--	--	--	--	--	--	--		

Maximum of 9 records:

a. San Fernando 1971, Pacoima,
3 components

b. El Centro 1940, 2 components

c. Koyna 1967, 2 components

d. Parkfield 1966, Cholame, 1 component

e. Port Hueneme 1957, 1 component

Helena 1935, Carroll College, E-W

Helena 1935, Carroll College, E-W

Helena 1935, Carroll College, E-W

Parkfield 1966, Temblor No. 2, S 25 W

Parkfield 1966, Temblor No. 2, S 25 W

Parkfield 1966, Temblor No. 2, S 25 W

Oroville 1975, Oroville Dam, N 53 W

Oroville 1975, Oroville Dam, N 53 W

Oroville 1975, Oroville Dam, N 53 W

San Fernando 1971, Griffith Park, N-W

San Fernando 1971, Griffith Park, N-W

San Fernando 1971, Griffith Park, N-W

Maximum of 9 records:

- a. San Fernando 1971, Pacoima, 3 components
- b. El Centro 1940, 2 components
- c. Koyna 1967, 2 components
- d. Parkfield 1966, Cholame, 1 component
- e. Port Hueneme 1957, 1 component

Helena 1935, Carroll College, E-W
 Helena 1935, Carroll College, E-W
 Helena 1935, Carroll College, E-W
 Parkfield 1966, Temblor No. 2, S 25 W
 Parkfield 1966, Temblor No. 2, S 25 W
 Parkfield 1966, Temblor No. 2, S 25 W
 Oroville 1975, Oroville Dam, N 53 W
 Oroville 1975, Oroville Dam, N 53 W
 Oroville 1975, Oroville Dam, N 53 W
 San Fernando 1971, Griffith Park, N-W
 San Fernando 1971, Griffith Park, N-W
 San Fernando 1971, Griffith Park, N-W

(Continued)

(Sheet 1 of 3)

Table 1 (Continued)

η	q	$\frac{y}{h_1}$										$\frac{y - h_1 + h_2}{h_2}$				Damping Percent	Accelerogram
		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0						
0	0	2.01	1.90	1.73	1.54	1.31	--	--	--	--	--	--	--	--	--	20	San Fernando 1971, Castaic N 69 W
0.5	0.185	2.26	2.13	1.88	1.68	1.48	--	--	--	--	--	--	--	--	--	15	San Fernando 1971, Castaic N 69 W
0.5	0.5	2.47	2.38	2.24	2.02	1.82	--	--	--	--	--	--	--	--	--	15	San Fernando 1971, Castaic N 69 W
0	0	2.19	1.96	--	--	--	--	--	--	--	--	--	--	--	--	15	San Fernando 1971, Castaic N 21 E
0.5	0.185	2.57	2.22	--	--	--	--	--	--	--	--	--	--	--	--	15	San Fernando 1971, Castaic N 21 E
0.5	0.5	2.09	2.52	2.26	--	--	--	--	--	--	--	--	--	--	--	15	San Fernando 1971, Castaic N 21 E
0.5	0.5	4.36	4.02	3.61	3.19	2.73	2.21	1.84	1.65	1.53	1.44	--	--	--	--	15	El Centro Array No. 10, Keystone Road, N 50 E, 10/15/79
1.00	0.5	3.43	3.26	3.03	2.78	2.50	2.15	1.97	1.79	1.73	1.67	--	--	--	--	15	El Centro Array No. 10, Keystone Road, N 50 E, 10/15/79
0.5	0.5	3.30	3.14	2.85	2.55	2.39	2.16	1.97	1.84	1.75	1.66	--	--	--	--	15	Imperial Valley Earthquake, Holtville Post Office, S 45 W, 10/15/79
1.0	0.5	2.70	2.60	2.54	2.44	2.30	2.13	2.02	1.91	1.85	1.78	--	--	--	--	15	Imperial Valley Earthquake, Holtville Post Office, S 45 W, 10/15/79
0.5	0.5	4.58	4.40	4.12	3.78	3.38	2.91	2.44	2.17	1.99	1.85	--	--	--	--	15	Imperial Valley Earthquake, Holtville Post Office, N 45 W, 10/15/79
1.0	0.5	3.92	3.81	3.63	3.41	3.15	2.86	2.67	2.47	2.38	2.29	--	--	--	--	15	Imperial Valley Earthquake, Holtville Post Office, N 45 W, 10/15/79
0.5	0.5	4.01	3.81	3.49	3.08	2.64	2.19	1.79	1.60	1.50	1.39	--	--	--	--	15	Western Washington Earthquake, U. S. Army Base STA 0000, S 02 W, 4/13/49
1.0	0.5	3.24	3.08	2.85	2.59	2.38	2.14	1.99	1.83	1.76	1.68	--	--	--	--	15	Western Washington Earthquake, U. S. Army Base STA 0000, S 02 W, 4/13/49
0.5	0.5	3.95	3.75	3.44	3.09	2.72	2.26	1.83	1.60	1.51	1.44	--	--	--	--	15	Imperial Valley Earthquake, El Centro Array No. 3, Pine Union School, S 40 E, 10/15/79
1.0	0.5	3.25	3.14	2.97	2.75	2.50	2.22	2.05	1.87	1.79	1.71	--	--	--	--	15	Imperial Valley Earthquake, El Centro Array No. 3, Pine Union School, S 40 E, 10/15/79
0.5	0.5	3.32	3.21	3.02	2.78	2.49	2.14	1.84	1.65	1.53	1.43	--	--	--	--	15	Imperial Valley Earthquake, El Centro Array No. 3, Pine Union School, S 50 W, 10/15/79
1.0	0.5	2.78	2.71	2.62	2.48	2.30	2.09	1.98	1.86	1.81	1.75	--	--	--	--	15	Imperial Valley Earthquake, El Centro Array No. 3, Pine Union School, S 50 W, 10/15/79
0.5	0.5	3.13	2.93	2.63	2.35	2.09	1.80	1.53	1.40	1.32	1.25	--	--	--	--	15	El Centro Array No. 10, Keystone Road, N 40 W, 10/15/79
1.0	0.5	2.41	2.35	2.24	2.11	1.95	1.77	1.66	1.54	1.50	1.46	--	--	--	--	15	El Centro Array No. 10, Keystone Road, N 40 W, 10/15/79

(Continued)

(Sheet 2 of 3)

Table 1 (Concluded)

		$\frac{y - b_1 + b_2}{b_2}$									
		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
		<u>Summary Values of Amplification Factors</u>									
Average		2.95	2.77	2.61	2.40	2.17	2.14	1.98	1.83	1.76	1.69
(σ)		(0.58)	(0.54)	(0.50)	(0.46)	(0.44)	(0.29)	(0.25)	(0.25)	(0.25)	(0.25)
Average + σ		3.53	3.31	3.11	2.86	2.61	2.43	2.23	2.08	2.01	1.94
Maximum		4.58	4.40	4.12	3.78	3.38	2.91	2.67	2.47	2.38	2.29

APPENDIX A

TABLES OF SLIDING BLOCK CALCULATIONS FOR STRONG-MOTION DATA FROM
EARTHQUAKES OF THE WESTERN UNITED STATES AND OTHER COUNTRIES, AND
SYNTHETIC ACCELEROGRAMS

Table A1
Strong-Motion Data, Earthquakes of Western United States (Uniformly Processed at California
Institute of Technology), and Other Countries

CIT File No.	Site Classifi- cation ^a	Recording Station	Date of Earthquake	Epicenter Location	Instrument Component	A Acceleration cm/sec ²	V Peak Velocity cm/sec	D Displace- ment cm	B Richter Magnitude	Modified Richter Intensity	Values of α (cm) for $H/A =$							
											0.02	0.1	0.5					
A001	I	El Centro Site, Imperial Valley	5-18-40	32°45' N 115°27' W	S 90° E Up	243.7 210.1	33.4 36.9	10.9 19.8	9.3	6.7	VIII	30 53	161.3 191.8	(190.7) ^b (211.9)	38.85 57.68	(51.87) ^b (49.9)	1.34 1.88	(0.59) ^b (1.23)
A002	I	Northwest California Earth- quake, Ferndale City Hall	10-7-51	40°13' N 122°48' W	S 44° W Up	102.0 109.5	4.8 7.4	2.4 2.7	56.3		V							
A003	A	Kern County Earthquake, Artesium	7-21-52	35°00' N 119°02' W	S 100° E Up	46.5 52.1	6.2 9.1	2.7 3.0	126.0	7.7	VII	50 50	84.08 (131.13)	(80.35)	34.17 (43.71)	(21.03)	1.51	(0.94) (2.57)
A004	A	Kern County Earthquake, Tart Lincoln School	7-21-52	35°00' N 119°02' W	S 21° E Up	152.7 175.9	15.7 17.7	6.7 9.2	43.0	7.7	VII	54 54	92.82 112.2	(101.2)	29.54 (38.91)	28.54 (36.16)	0.73 0.91	(0.84) (1.23)
A005	A	Kern County Earthquake, Santa Barbara Courthouse	7-21-52	35°00' N 119°02' W	N 42° E Up	87.8 128.6	11.8 19.3	4.6 5.8	89.5	7.7	VII	54 60	124.33 119.6	(148.1)	46.15 (44.34)	43.45 (46.34)	1.05 2.23	(3.71) (0.00)
A006	A	Kern County Earthquake, Mojave Storage Basement	7-21-52	35°00' N 119°02' W	S 90° E Up	54.1 22.5	6.1 4.2	5.1 2.2	119.5	7.7	VII	82 82	68.71 93.24	(95.26)	22.15 (30.78)	20.13 (26.78)	0.58 1.14	(0.53) (1.16)
A007	A	Kern County Earthquake, Mojave Storage P & Lot	7-21-52	35°00' N 119°02' W	S 90° E Up	58.1 44.1	6.6 4.5	4.5 3.4	119.5	7.7	VII	79 79	79.10 94.98	(108.11)	23.39 (31.26)	0.405 1.67	(0.61) (1.44)	
A008	I	Eureka Earthquake, Eureka Federal Building	12-21-54	32°38' N 117°07' W	N 11° W Up	164.5 25.7	21.6 8.2	12.4 4.7	24.0	6.5	VII	26(34) 30	205.17 105.01	(141.44)	40.67 (34.53)	2.19 1.96	(0.53) (1.74)	
A009	I	Eureka Earthquake, Ferndale City Hall	12-21-54	32°38' N 117°07' W	N 44° E Up	155.7 81.3	35.6 18.7	14.2 4.7	40.4	6.5	VII	20(31) 20(30)	292.22 137.05	(286.82)	91.98 (28.09)	9.04 2.36	(4.88) (0.48)	
A010	A	San Jose Earthquake, San Jose Bank of America Basement	9-4-55	37°22' N 121°53' W	N 31° W Up	100.2 105.8	10.8 4.4	2.8 1.7	9.8	5.5	VII	30 30	17.58 (30.50)	4.54 (12.31)	(4.66)	0.35	(0.24) (0.14)	
A011	A	El Alamo, Baja California Earthquake, El Centro Site, Imperial Valley Irrigation District	2-9-56	31°45' N 115°55' W	S 00° W Up	32.4 30.1	4.0 7.0	2.4 4.1	125.9	6.8	VI	70 70		(76.25)	(26.27)	30.51	(20.22)	(0.89) (6.56)
A012	A	El Alamo, Baja California Earthquake, El Centro Site, Imperial Valley Irrigation District (Mierloch)	2-9-56	31°45' N 115°55' W	S 00° W Up	11.8 13.4	1.9 2.7	1.7 2.9	125.9									
A013	I	San Francisco Earthquake, San Francisco Pacific	3-22-57	37°40' N 122°29' W	N 45° S Up	45.9 44.9	2.9 5.0	1.1 1.4	16.8	5.3	VII	26 26		(12.93)	8.80 (10.41)	(3.99)	0.24	(0.08) (0.72)
A014	I	San Francisco Earthquake, San Francisco Alexander Building Basement	3-22-57	37°40' N 122°29' W	N 09° W Up	41.8 43.4	2.9 2.1	1.3 1.0	15.2	5.3	VII	25		4.93 (4.95)	1.45 (1.35)	0.11	(0.05)	
A015	I	San Francisco Earthquake, San Francisco Golden Gate Park	3-22-57	37°40' N 122°29' W	N 10° E Up	81.8 103.8	4.9 4.6	2.3 2.8	11.8	5.3	VII	12		7.89 (2.76)	1.49 (0.82)	0.06	(0.09)	
A016	I	San Francisco Earthquake, San Francisco State Building Basement	3-22-57	37°40' N 122°29' W	S 09° W Up	83.8 55.1	5.1 2.0	1.1 0.6	14.6	5.3	VII							
A017	I	San Francisco Earthquake, Oakland City Hall Basement	3-22-57	37°40' N 122°29' W	N 26° E Up	43.5 22.7	2.3 2.0	0.9 1.3	24.3	5.3	VI							

(Continued)

Notes: Locations in California unless otherwise noted.
^a A = alluvium; B = bedrock; and M = mixed rock.
^b Values in parentheses are for reversed direction of shaking.

(Continued)

Table A1 (Continued)

CITY No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Acceleration cm/sec ²	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M _s	Modified Mercalli Intensity	Duration sec	Values of μ (m) for $M/A =$		
													0.02	0.1	0.5
A018	Bellevue Earthquake, Bellevue City Hall	A	4-8-61	36°40' N 121°18' W	S 01° W Up	63.4 17.1 4.1	7.8 1.7 0.7	2.8 0.8 0.3	40.0	5.6	VII	30	58.58 (85.54)	12.98 (19.14)	0.23 (0.89)
A019	Barro Colorado Earthquake, El Centro Site, Imperial Valley Irrigation District	A	4-8-66	33°09' N 116°08' W	S 00° W Up	127.8 25.8 1.5	12.2 2.5 0.9	12.2 3.0 1.3	69.8	6.5	VI	60	169.27 (306.78)	43.75 (53.13)	0.99 (1.46)
A020	Barro Colorado Earthquake, San Diego Light & Power Building	A	4-8-66	33°09' N 116°08' W	S 00° W Up	29.5 6.0 1.3	3.4 0.6 0.3	4.4 1.3 0.5	109.9	6.5	VI	30			
B021	Long Beach Earthquake, Vernon CBD Building	A	3-10-33	33°35' N 117°59' W	S 08° E Up	130.6 28.7 1.5	15.5 3.7 1.3	7.4 1.7 0.7	47.8	6.3	VI	30	156.41 (216.33)	30.27 (37.21)	0.88 (0.50)
B022	Southern California Earthquake, Bollywood Storage Building, Pechhouse	A	10-2-33	33°47' N 116°08' W	S 00° E Up	43.3 10.4 2.8	5.2 1.8 0.9	1.8 0.5 0.3	38.2	5.4	V				
B023	Southern California Earthquake, Bollywood Storage Building, Basement	A	10-2-33	33°47' N 116°08' W	S 00° E Up	32.1 7.6 2.2	2.0 0.8 0.4	0.8 0.3 0.1	38.2	5.4	V				
B024	Lower California Earthquake, El Centro Imperial Valley	A	12-30-34	32°12' N 115°30' W	S 00° E Up	156.8 37.1 1.5	20.5 4.2 1.5	4.2 1.5 0.5	60.8	6.5	VI	30	89.64 (81.21)	24.96 (28.65)	0.31 (0.47)
B025	Meina, Montana Earthquake, Meina, Montana, Carroll College	IR	10-31-35	46°37' N 111°58' W	S 00° E Up	143.5 33.3 1.5	7.3 1.4 0.5	1.4 0.5 0.2	6.6	6.0	VII	5	25.07 (23.59)	6.33 (6.83)	0.29 (0.66)
B026	1st Northwest California Earthquake, Ferndale City Hall	I	9-11-38	40°18' N 124°48' W	S 45° W Up	140.9 31.6 1.4	6.6 1.6 0.6	3.9 1.6 0.6	55.3	5.5	VI	20	(19.17)	(4.29)	(0.19)
B027	2nd Northwest California Earthquake, Ferndale City Hall	I	2-9-41	40°54' N 125°54' W	S 45° W Up	61.3 34.4 1.5	3.5 2.0 0.8	2.0 1.4 0.6	98.4	6.6	VI				
B028	Western Washington Earthquake, District Engineers Office at Army Base	A	4-13-49	48°06' N 122°42' W	S 02° W Up	66.5 15.2 2.1	8.2 2.4 1.5	2.4 1.5 0.8	57.8	7.1	VIII	40	(126.89)	(54.19)	(1.81)
B029	Western Washington Earthquake, Olympia, Washington, Highway Test Laboratory	A	4-13-49	48°06' N 122°42' W	S 04° E Up	274.6 65.9 2.7	17.0 7.9 2.7	10.4 2.7 2.3	16.8	7.1	VIII	50	(249.95)	(63.19)	(1.13)
B030	Northern California Earthquake, Ferndale City Hall	I	9-22-52	40°12' N 124°25' W	S 44° W Up	53.1 74.1 2.9	6.9 4.7 1.9	2.0 1.9 1.5	43.2	5.5	VI	26	131.24 (131.66)	28.78 (33.78)	0.12 (0.66)
B031	Wheeler Ridge, California Earthquake, Teft Lincoln School Tunnel	A	1-12-54	35°00' N 119°01' W	S 21° E Up	63.9 13.4 3.5	5.8 2.4 2.9	1.7 1.1 1.1	43.0	5.9	VII	20	(21.37)	(5.05)	(0.32)
B032	Puget Sound, Washington Earth- quake, Olympia, Washington, Highway Test Laboratory	A	4-29-65	47°24' N 122°18' W	S 04° E Up	134.2 194.3 5.9	8.0 12.7 3.0	2.7 3.8 1.7	61.1	6.5	VII	50	(62.0)	(15.98)	(0.24)
B033	Pasadena, California Earth- quake, Chollame, Shandon Array No. 2	A	6-27-66	35°54' N 120°54' W	S 65° E Down	479.6 202.2 14.1	77.9 26.3 4.3	26.3 4.3 2.1	31.9	5.6	VII	12	353.0 (253.3)	68.3 (67.1)	1.14 (0.48)
B034	Pasadena, California Earth- quake, Chollame, Shandon Array No. 5	A	6-27-66	35°54' N 120°54' W	S 85° E Down	347.8 425.7 116.9	22.5 25.4 6.8	5.2 7.1 3.4	32.4	5.6	VI	15	(42.36)	(11.64)	(1.31)
B035	Pasadena, California Earth- quake, Chollame, Shandon Array No. 8	A	6-27-66	35°54' N 120°54' W	S 10° E Down	232.6 269.6 77.7	10.8 11.8 4.5	4.4 3.9 2.1	34.1	5.6	VI	26	(40.77)	(6.47)	(0.10)
B036	Pasadena, California Earth- quake, Chollame, Shandon Array No. 12	A	6-27-66	35°54' N 120°54' W	S 10° E Down	52.1 63.2 44.6	7.0 8.0 5.0	4.1 5.7 2.6	36.5	5.6	VI	40	70.08 (80.20)	13.57 (18.63)	0.004 (0.14)

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Table A1 (Continued)

CIT File No.	Recording Station	Site Classifi- cation	Date of Earthquake	Epicenter Location	Instrument Component	A			Peak Displace- ment cm	Epicentral Distance km	Richter Magnitude M	Modified Intensity	Duration sec	Values of μ (cm) for $M/A =$		
						Peak Acceleration cm/sec ²	Peak Velocity cm/sec	V						0.02	0.1	0.5
B037	Parkfield, California Earth- quake Tumbler No. 2	MR	6-27-66	35°54' N 120°54' W	N 65° W S 25° W Down	264.3 340.8 129.8	14.5 22.5 4.4	4.7 5.5 1.4	31.0	5.6	VII	25 22	31.94 (47.24)	8.32 (10.84)	0.24 (0.80)	
B038	Parkfield, California Earth- quake, San Luis Obispo Recreation Building	I	6-27-66	35°54' N 120°54' W	N 36° W S 54° W Up	14.2 11.4 6.1	1.1 0.8 1.3	1.1 0.6 0.9	76.1	5.6	V	29	10.38 (9.24)	1.85 (1.64)	0.024 (0.028)	
B039	2nd Northern California Earth- quake, Rureha Federal Building	I	12-10-67	40°30' N 124°36' W	S 11° E N 79° E Down	20.4 19.5 7.7	2.3 2.8 1.5	0.9 1.4 1.3	50.6	5.8	V	29	8.845 (7.96)	1.65 (1.73)	0.088 (0.032)	
B040	Borrego Mountain Earthquake, San Onofre SCE Power Plant	I	4-8-68	33°09' N 116°08' W	N 33° E S 57° W Down	40.0 45.5 34.2	3.7 4.2 2.9	1.6 2.5 1.7	134.4	6.5	V	40	23.22 (20.00)	3.88 (4.96)	0.012 (0.136)	
C041	San Fernando Earthquake, Pacoima Dam	MR	2-9-71	34°24' N 118°23' 42" W	S 16° E S 74° W Down	1148.1 1054.9 696.0	113.2 97.7 58.3	37.7 10.8 19.3	9.1	6.6	X	16 14	287.3 234.2	124.5 (170.7)	71.0 (54.28)	0.11 (0.76)
C042	San Fernando Earthquake, Aftershock at 52.6 sec, Pacoima Dam		2-9-71	34°24' N 118°23' 42" W	S 74° W S 16° E Down	27.1 20.7 8.2	2.9 1.5 1.1	1.7 0.9 1.0	22.4	6.6	VII	41 41	306.7 (354.3)	97.2 (127.9)	0.97 (2.34)	
C044	San Fernando Earthquake, Aftershock at 104.6 sec, Pacoima Dam		2-9-71	34°24' N 118°23' 42" W	S 74° W S 16° E Down	109.9 113.2 40.5	4.8 4.7 2.3	2.2 2.3 1.0								
C048	San Fernando Earthquake, 8244 Orion Boulevard, 1st Floor, Holiday Inn	A	2-9-71	34°24' N 118°23' 42" W	N 00° W S 90° W Down	250.0 131.7 167.5	30.0 23.9 32.0	14.9 13.8 14.6								
C051	San Fernando Earthquake, 250 East First Street, Basement, Los Angeles	A	2-9-71	34°24' N 118°23' 42" W	N 36° E N 54° W Down	97.8 122.7 48.0	17.1 21.9 7.8	9.2 11.6 5.8	42.8	6.6	VII	15 15	143.8 (173.6)	32.44 (36.35)	1.212 (0.12)	(0.36)
C054	San Fernando Earthquake, 445 Figueroa Street, Subbasement, Los Angeles	I, A	2-9-71	34°24' N 118°23' 42" W	N 52° W S 38° W Down	147.1 117.0 51.7	17.4 10.7 10.7	11.8 11.8 3.1								(0.74)
D056	San Fernando Earthquake, Old Ridge Route, Catalic	I	2-9-71	34°24' N 118°23' 42" W	N 21° E N 69° W Down	309.4 265.4 153.3	16.5 27.2 6.2	4.2 9.3 3.5	28.6	6.6	VI	30 30	42.06 (39.86)	9.50 (25.08)	0.03 (1.36)	(0.53)
D057	San Fernando Earthquake, Hollywood Storage Basement	A	2-9-71	34°24' N 118°23' 42" W	S 00° W N 90° E Up	103.8 148.2 49.8	17.0 19.4 8.0	8.6 13.1 3.8	37.1	6.6	VII	40 40	125.29 (124.18)	37.02 (29.78)	0.92 (1.52)	(1.03)
D058	San Fernando Earthquake, Hollywood Storage P. E. Lot	A	2-9-71	34°24' N 118°23' 42" W	N 90° E S 00° W Up	167.3 207.0 87.0	16.5 21.1 3.0	8.0 14.7 3.0	37.1	6.6	VII	21 21	82.66 (82.01)	18.55 (39.78)	0.43 (1.61)	(0.35)
D059	San Fernando Earthquake, 1901 Avenue, The Stars Subbasement	A	2-9-71	34°24' N 118°23' 42" W	N 46° W S 44° W Down	133.8 147.1 66.7	9.6 16.7 4.8	7.5 12.2 2.5	39.8	6.6	VII	55 55	70.73 (85.42)	12.60 (10.88)	0.14 (0.23)	(0.22)
D062	San Fernando Earthquake, 1640 South Marengo Street, 1st Floor, Los Angeles	A	2-9-71	34°24' N 118°23' 42" W	N 38° W S 52° W Down	118.0 130.0 74.6	16.1 17.6 9.0	12.0 6.9 4.1	42.8	6.6	VII	30 30	117.94 (117.70)	32.64 (35.02)	1.40 (1.83)	(0.79)
D065	San Fernando Earthquake, 3710 Wilshire Boulevard, Basement, Los Angeles	A, I	2-9-71	34°24' N 118°23' 42" W	S 00° W S 90° W Down	146.7 155.7 73.1	18.0 22.1 9.0	10.3 12.9 4.9	40.0		VII	17 17	73.76 (98.72)	16.34 (38.88)	0.17 (0.72)	(0.64)
D068	San Fernando Earthquake, 7080 Hollywood Boulevard, Basement, Los Angeles	A	2-9-71	34°24' N 118°23' 42" W	N 00° E N 90° E Down	81.2 98.0 57.2	12.6 13.3 3.6	6.1 7.2 4.2	35.0	6.6	VII					
E071	San Fernando Earthquake, Wheeler Ridge	A	2-9-71	34°24' N 118°23' 42" W	S 00° W N 90° E Down	26.5 25.3 13.0	1.9 2.5 2.4	1.4 2.1 3.3	86.0	6.6	V					
E072	San Fernando Earthquake, 4680 Wilshire Boulevard, Basement, Los Angeles	I	2-9-71	34°24' N 118°23' 42" W	N 75° W N 15° E Down	82.2 115.0 64.8	20.8 21.5 6.9	14.7 11.7 3.2	39.5	6.6	VII	18 18 18	132.43 (161.58)	55.79 (65.79)	0.73 (0.43)	(1.20)

(Continued)

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Table A1 (Continued)

CIT File No.	Recording Station	Site Classifi- cation	Date of Earthquake	Epicenter Location	Instrument Component	Peak Acceleration cm/sec ²	V Velocity cm/sec	Peak Displace- ment cm	Epicentral Distance km	Richter Magnitude M _L	Modified Mercalli Intensity	Duration sec	Values of μ (cm) for $\mu/\lambda =$		
													0.02	0.1	0.5
E075	San Fernando Earthquake, 3470 Wilshire Boulevard, Subbasement, Los Angeles	A	2-9-71	34°24' N 118°23.7' W	S 00° E S 90° W	133.8 111.8	22.3 18.5	11.4 11.6	40.1	6.6	VII	22	164.64 (191.40)	38.65 (48.06)	1.70 (1.33)
E078	San Fernando Earthquake, Water and Power Building, Basement, Los Angeles	I	2-9-71	34°24' N 118°23.7' W	S 00° E S 40° W	126.5 169.2	23.2 16.1	13.7 8.9	42.5	6.6	VII	17	163.38 (161.64)	33.18 (34.46)	1.99 (0.12)
E081	San Fernando Earthquake, Santa Felicia Dam, Outlet Works	I	2-9-71	34°24' N 118°23.7' W	S 08° E S 82° W	213.0 198.3	9.9 6.2	7.0 4.6	32.9	6.6	VI	34	20.97 (24.75)	2.61 (3.08)	(0.05) (0.08)
E082	San Fernando Earthquake, Santa Felicia Dam, Crest		2-9-71	34°24' N 118°23.7' W	S 15° E S 75° W	203.3 174.0	22.2 18.1	7.1 5.3	32.8	6.6	VI	37	213.32 (213.32)	31.63 (34.64)	1.69 (1.20)
E083	San Fernando Earthquake, 3407 61st Street, Basement, Los Angeles	A	2-9-71	34°24' N 118°23.7' W	S 00° E S 90° E	158.2 161.9	18.3 16.5	9.0 10.3	40.0	6.6	VII	25	103.51 (107.32)	29.21 (26.24)	0.80 (0.06)
F086	San Fernando Earthquake, Verzon, CND Building	A	2-9-71	34°24' N 118°23.7' W	S 07° W Up	104.6 80.5	17.4 15.1	14.8 10.7	49.4	6.6	V	25	190.16 (132.27)	38.49 (30.68)	1.47 (0.23)
F087	San Fernando Earthquake, Engineering Building, Santa Ana, Orange County	A	2-9-71	34°24' N 118°23.7' W	S 04° E S 86° W	26.8 28.2	5.0 8.0	3.6 5.7	88.5	6.6	VI		88.33 (121.6)	37.67 (31.77)	0.31 (0.20)
F088	San Fernando Earthquake, 633 East Broadway, Municipal Service Building, Glendale	A, I	2-9-71	34°24' N 118°23.7' W	S 70° E S 20° W	265.7 209.1	30.7 23.5	11.1 5.3	34.1	6.6	VII	27	156.08 (179.32)	66.55 (62.85)	2.61 (1.98)
F089	San Fernando Earthquake, 800 South Olive Street, Los Angeles	A	2-9-71	34°24' N 118°23.7' W	S 53° E S 37° W	131.9 139.0	20.8 20.7	14.5 11.6	44.0	6.6	VII	22	119.60 (122.68)	29.28 (26.51)	0.12 (0.53)
F092	San Fernando Earthquake, 2011 Zonal Avenue, Basement, Los Angeles	I	2-9-71	34°24' N 118°23.7' W	S 62° E S 28° W	64.2 79.1	13.8 11.5	10.3 6.3	43.1	6.6	VII		104.71 (68.54)	24.62 (23.40)	(0.16)
F095	San Fernando Earthquake, 120 North Robertson Boulevard, Subbasement, Los Angeles	A	2-9-71	34°24' N 118°23.7' W	S 48° E S 02° W	96.2 83.9	16.8 17.9	10.6 12.1	37.4	6.6	VII		152.37 (152.37)	55.37 (55.37)	(1.90)
F098	San Fernando Earthquake, 646 South Olive Avenue, Basement, Los Angeles	A	2-9-71	34°24' N 118°23.7' W	S 53° E S 37° W	236.4 192.0	21.8 18.5	13.2 13.4	42.7	6.6	VII	22	94.08 (75.18)	9.24 (14.67)	0.04 (0.42)
F101	San Fernando Earthquake, Edison Company, Cotton Port Tejon, Tejon	A	2-9-71	34°24' N 118°23.7' W	S 00° W S 90° E	37.5 30.0	2.5 2.2	1.1 1.3	107.6	6.6	V		6.35 (5.55)	2.56 (2.65)	0.20 (0.16)
F102	San Fernando Earthquake, Port Tejon, Tejon	IR	2-9-71	34°24' N 118°23.7' W	S 00° E S 90° E	24.6 20.6	1.4 1.3	0.8 0.7	68.5	6.6	V		2.08 (3.41)	0.57 (1.30)	0.01 (0.03)
F103	San Fernando Earthquake, Pasadena Pl., Pasadena	A	2-9-71	34°24' N 118°23.7' W	S 00° E S 90° W	91.5 120.5	4.4 5.4	2.5 2.4	45.4	6.6	V		31.33 (30.68)	8.34 (9.60)	0.15 (0.23)
F104	San Fernando Earthquake, Emping Plant, Gorman	I	2-9-71	34°24' N 118°23.7' W	S 00° E S 90° W	85.2 105.1	8.5 6.0	2.0 2.3	52.2	6.6	V		13.44 (15.39)	2.72 (2.96)	0.09 (0.02)
F105	San Fernando Earthquake, RCA Monitor Laboratory, Los Angeles	A	2-9-71	34°24' N 118°23.7' W	S 00° W S 90° E	83.1 77.6	8.3 7.6	4.0 4.5	38.7	6.6	VII		60.01 (49.82)	9.86 (8.65)	0.26 (0.24)
G106	San Fernando Earthquake, CIT Seismological Laboratory, Pasadena	IR	2-9-71	34°24' 42" N 118°24' 00" W	S 00° W S 90° E	87.5 188.6	5.8 11.6	1.6 2.3	36.1	6.6	VII	25	31.17 (36.24)	8.20 (10.63)	0.62 (0.39)
G107	San Fernando Earthquake, Athenaeum, CIT	A	2-9-71	34°24' 42" N 118°24' 00" W	S 00° E S 90° E	93.5 107.3	7.9 14.3	3.0 2.3	39.8	6.6	VII	26	63.01 (139.12)	32.01 (33.54)	0.38 (2.00)

(Continued)

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Table A1 (Continued)

GIT File No.	Recording Station	Site Classifi- cation	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec ²	V Peak Velocity cm/sec	P Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Herculite Intensity	Duration sec	Values of α (cm) for $M/A =$		
													0.02	0.1	0.5
G108	San Fernando Earthquake, CIT William Library	A	2-9-71	34°26'42" N 118°24'00" W	H 00° E S 90° E Down	188.0 181.6 91.2	9.8 16.3 8.7	2.7 6.9 2.4	39.8	6.6	VII	35	56.12 (91.73)	11.49 (20.33)	0.01 (0.77)
G110	San Fernando Earthquake, CIT Los Angeles Laboratory	A, I	2-9-71	34°26'42" N 118°24'00" W	S 82° E S 48° W Down	207.8 139.0 126.3	13.6 9.0 5.7	5.0 2.9 2.6	31.5	6.6	VII	23	57.20 (33.63)	12.96 (11.07)	0.25 (0.02)
G112	San Fernando Earthquake, 111 West 34th Street, Beverly Hills	A	2-9-71	34°26'42" N 118°24'00" W	H 52° E S 34° E Down	101.9 75.3 53.2	17.0 15.7 9.9	11.0 8.2 5.2	40.5	6.6	VII	45	101.24 (113.98)	20.06 (21.98)	0.17 (0.18)
G114	San Fernando Earthquake, Plastic Tire Co., Storage Room, Philadel- phia	A	2-9-71	34°26'42" N 118°24'00" W	S 60° E S 30° W Down	110.8 132.2 88.6	16.0 22.7 7.6	3.8 2.7 2.4	32.3	6.6	VI	30	108.79 (126.65)	41.74 (48.10)	0.95 (0.03)
H115	San Fernando Earthquake, 3250 Ventura Boulevard, Beverly Hills	A	2-9-71	34°26'42" N 118°24'00" W	H 11° E S 79° W Down	220.6 225.5 94.5	28.2 25.5 9.3	13.4 14.3 4.3	29.3	6.6	VII	39	271.08 (281.37)	55.15 (74.89)	0.93 (1.26)
H118	San Fernando Earthquake, 8639 Lincoln Avenue, Beverly Hills	A	2-9-71	34°26'42" N 118°24'00" W	S 45° E S 45° W Down	33.7 32.7 41.0	11.8 11.4 6.1	8.8 6.1 3.9	50.2	6.6	VI	76	281.78 (251.62)	114.86 (47.10)	1.65 (0.44)
H121	San Fernando Earthquake, 900 South Fremont Avenue, Beverly Hills	A	2-9-71	34°26'42" N 118°24'00" W	S 90° W S 90° W Down	119.4 122.5 79.2	17.1 10.5 8.2	8.6 4.4 3.4	41.1	6.6	VII	27	132.73 (113.87)	35.26 (21.56)	1.39 (0.53)
H124	San Fernando Earthquake, 2400 Belmont Avenue, Beverly Hills	A	2-9-71	34°26'42" N 118°24'00" W	S 90° W S 90° W Down	34.9 34.5 14.7	4.4 3.8 2.3	2.1 2.7 1.9	76.8	6.6	VI	34	59.86 (31.23)	17.25 (20.08)	0.26 (0.11)
H128	San Fernando Earthquake, 435 North Oakhurst Avenue, Beverly Hills	A	2-9-71	34°26'42" N 118°24'00" W	H 00° E S 90° W Down	60.9 91.6 36.4	13.2 15.0 3.8	7.2 8.1 2.3	38.2	6.6	VI	20	84.11 (98.55)	13.32 (24.23)	0.11 (0.72)
H131	San Fernando Earthquake, 450 North Hollywood Drive, 1st Floor, Beverly Hills	A	2-9-71	34°26'42" N 118°24'00" W	H 50° E H 40° W Down	164.3 160.6 37.2	17.2 14.1 4.5	9.2 6.1 2.3	38.9	6.6	VII	49	205.96 (161.37)	47.85 (35.33)	0.46 (1.23)
H134	San Fernando Earthquake, 1800 Century Park East, Basement (PS), Los Angeles	A	2-9-71	34°26'42" N 118°24'00" W	S 81° E S 09° W Down	140.2 129.0 99.9	16.1 22.3 7.9	7.1 2.8 2.6	29.0	6.6	VII	39	235.53 (121.04)	101.38 (43.94)	0.46 (1.23)
J137	San Fernando Earthquake, 15910 Ventura Boulevard, Basement, Los Angeles	IR	2-9-71	34°26'42" N 118°24'00" W	H 21° E S 69° E Down	145.5 108.9 93.0	18.0 14.4 11.7	3.4 2.9 2.9	29.6	6.6	VI	22	87.29 (88.40)	27.38 (21.89)	0.84 (0.34)
J141	San Fernando Earthquake, Lahr Hughes Array No. 1	IR	2-9-71	34°26'42" N 118°24'00" W	S 69° E S 21° W Down	168.2 143.5 150.8	5.3 8.6 6.8	1.2 1.7 1.6	26.8	6.6	VI	37	22.57 (26.33)	5.97 (4.00)	0.14 (0.36)
J143	San Fernando Earthquake, Lahr Hughes Array No. 9	IR	2-9-71	34°26'42" N 118°24'00" W	H 21° E H 69° W Down	119.3 109.4 71.5	4.8 4.3 2.9	2.0 2.4 2.2	26.6	6.6	VI	27	13.71 (13.20)	3.86 (2.12)	0.17 (0.04)
J144	San Fernando Earthquake, Lahr Hughes Array No. 12	I	2-9-71	34°26'42" N 118°24'00" W	H 21° E H 69° W Down	346.2 277.9 105.3	14.7 12.4 4.1	1.8 8.9 3.3	23.3	6.6	VI	22	30.15 (27.99)	6.63 (8.29)	0.76 (0.43)
J145	San Fernando Earthquake, 15107 Van Owen Street, Basement, Los Angeles	A	2-9-71	34°26'42" N 118°24'00" W	S 00° W S 90° W Down	113.9 103.4 106.4	31.5 17.3 18.1	17.5 15.3 7.0	34.9	6.6	VII	40	424.25 (411.18)	181.20 (160.29)	6.01 (3.57)
J148	San Fernando Earthquake, 616 South Normandie Avenue, Basement, Los Angeles	A, I	2-9-71	34°26'42" N 118°24'00" W	H 00° E S 90° W Down	107.6 112.0 51.6	16.2 17.5 5.6	7.3 11.1 3.4	39.9	6.6	VII	19	108.28 (128.51)	36.36 (43.20)	1.31 (0.41)
L166	San Fernando Earthquake, 3438 Lankershim Boulevard, Basement, Los Angeles	I	2-9-71	34°26'42" N 118°24'00" W	H 00° E S 90° W Down	164.2 147.6 69.7	12.3 15.0 5.0	4.9 5.4 2.4	30.8	6.6	VII	26	54.26 (67.07)	16.00 (12.95)	1.23 (0.13)

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Table A1 (Continued)

CII File No.	Recording Station	Site Classifi- cation	Date of Earthquake	Epicenter Location	Instrument Component	A Acceleration cm/sec ²	V Peak Velocity cm/sec	B Displace- ment cm	Epicentral Distance km	Richter Magnitude M _s	Modified Mercalli Intensity	Values of μ (cm) for $M/A =$		
												0.02	0.1	0.5
L171	San Fernando Earthquake, Nuclear Power Plant, San Onofre	I	2-9-71	34°24' N 118°23' 42" W	H 33° E S 57° W Down	12.0 15.9 10.3	1.8 2.8 2.0	2.1 2.1 2.0	139.8	6.6	V	16.07 (19.17)	2.56 (3.64)	0.03 (0.04)
M176	San Fernando Earthquake, 1150 South Hill Street, Subbasement, Los Angeles	A	2-9-71	34°24' N 118°23' 42" W	H 37° E S 53° E Down	83.4 116.0 41.6	20.9 17.7 8.9	13.7 13.7 4.3	42.9	6.6	VII	205.31 (214.21)	66.51 (72.27)	1.36 (1.37)
M179	San Fernando Earthquake, Tehachapi Pumping Plant, CMI Site, Grapevine	I	2-9-71	34°24' N 118°23' 42" W	S 00° E H 90° E Down	20.8 46.7 38.5	1.1 2.6 2.0	0.7 0.9 1.2	70.7	6.6	VI	4.48 (3.05)	1.23 (1.10)	0.06 (0.04)
M180	San Fernando Earthquake 4000 West Chapman Avenue, Basement, Orange	A	2-9-71	34°24' N 118°23' 42" W	S 00° E S 90° E Down	23.9 29.9 18.2	5.7 8.5 3.9	3.5 6.5 2.5	84.3	6.6	V	208.77 (196.69)	62.10 (66.93)	0.16 (0.19)
M183	San Fernando Earthquake, 6074 Park Drive, Ground level, Wrightwood	I	2-9-71	34°24' N 118°23' 42" W	H 65° E H 25° E Down	42.4 55.7 22.9	3.8 2.6 2.0	1.2 0.9 1.2	70.8	6.6	V	17.13 (23.32)	5.68 (6.47)	0.22 (0.06)
M184	San Fernando Earthquake, 6074 Park Drive, Ground level, Wrightwood	I	2-9-71	34°24' N 118°23' 42" W	H 65° E S 25° E Down	43.1 57.2 24.7	4.6 2.9 1.8	1.2 0.7 0.9	70.8	6.6	V	30.53 (19.53)	7.70 (6.28)	0.09 (0.31)
M185	San Fernando Earthquake, Carbon Canyon Dam	I	2-9-71	34°24' N 118°24' 00" W	S 50° E S 40° E Down	67.3 67.3 41.5	3.3 4.5 2.5	1.7 2.1 1.6	75.6	6.6	V	28.34 (27.89)	8.27 (8.24)	0.43 (0.18)
M186	San Fernando Earthquake, Whittier Narrows Dam	A	2-9-71	34°24' N 118°24' 00" W	S 37° E H 53° E Down	95.7 94.7 58.6	8.8 9.7 3.6	4.9 5.0 2.3	54.1	6.6	VI	86.14 (82.36)	11.52 (12.61)	0.26 (0.42)
M187	San Fernando Earthquake, San Antonio Dam, Ipsland	A	2-9-71	34°24' N 118°24' 00" W	H 75° E H 15° E Down	55.7 75.9 28.3	3.1 3.7 1.5	0.7 0.8 0.8	72.1	6.6	VI	18.39 (20.02)	6.91 (7.05)	0.31 (0.26)
M188	San Fernando Earthquake, 1880 Century Park East, Park- ing lot level, Los Angeles	A	2-9-71	34°24' N 118°24' 00" W	H 54° E H 36° E Down	114.6 126.5 62.5	17.0 22.1 5.0	10.8 5.4 2.4	38.9	6.6	VII	108.37 (104.39)	14.39 (20.83)	0.17 (1.15)
M191	San Fernando Earthquake, 25111a, Top of Grand Canyon, Palos Verdes Estates	I	2-9-71	34°24' N 118°24' 00" W	H 65° E S 25° E Down	24.7 40.1 18.9	4.1 5.0 2.2	2.6 3.4 1.4	67.8	6.6	VI	97.72 (84.10)	22.25 (12.71)	0.31 (0.31)
M192	San Fernando Earthquake, 2500 Wilshire Boulevard, Basement, Los Angeles	I	2-9-71	34°24' N 118°24' 00" W	H 28° E H 61° E Down	96.7 98.9 42.5	14.8 17.5 7.7	7.7 7.9 3.3	40.7	6.6	VII	114.39 (128.41)	27.29 (36.53)	0.46 (1.53)
M195	San Fernando Earthquake, San Juan Capistrano	A	2-9-71	34°24' N 118°24' 00" W	H 37° E S 14° E Down	31.0 35.0 25.8	4.6 8.0 4.9	2.4 8.0 3.8	122.6	6.6	V	46.42 (47.26)	13.46 (12.61)	0.09 (0.26)
M196	San Fernando Earthquake, Long Beach State College, Ground level	A	2-9-71	34°24' N 118°24' 00" W	H 76° E S 14° E Down	35.0 31.0 25.8	8.5 9.3 4.9	8.0 6.7 3.8	75.4	6.6	VI	158.84 (190.72)	50.28 (46.70)	0.82 (0.61)
M197	San Fernando Earthquake, Anaheim Port Office Storage Room, Main	A	2-9-71	34°24' N 118°24' 00" W	H 45° E S 45° E Down	25.4 32.4 14.0	2.2 2.2 1.4	1.0 1.0 1.1	185.0	6.6	V	18.23 (17.33)	5.23 (5.21)	0.17 (0.19)
O198	San Fernando Earthquake, Griffith Park Observatory, Los Angeles	III	2-9-71	34°24' N 118°24' 00" W	S 00° E S 90° E Down	176.0 170.0 120.0	20.5 17.5 7.42	7.28 5.45 3.38	34.0	6.6	VII	89.06 (85.24)	17.43 (14.11)	0.97 (1.04)
O199	San Fernando Earthquake, 1625 Olympic Boulevard, Los Angeles	A	2-9-71	34°24' N 118°24' 00" W	H 28° E H 62° E Down	137.0 148.0 148.0	17.60 21.50 10.40	8.78 15.00 5.74	42.0	6.6	VII	118.95 (100.90)	28.40 (31.46)	1.0103 (0.68)
O204	San Fernando Earthquake, 205 West Broadway, Long Beach	A	2-9-71	34°24' N 118°24' 00" W	H 00° E H 90° E Up	25.9 20.7 12.2	8.17 9.58 6.12	5.81 7.77 3.58	73.8	6.6	VI	266.90 (299.71)	117.04 (135.66)	3.50 (1.01)
O205	San Fernando Earthquake, Terminal Island, Long Beach	A	2-9-71	34°24' N 118°24' 00" W	H 21° E S 69° E Up	28.4 28.1 16.1	7.37 10.30 4.24	6.39 8.72 2.83	73.6	6.6	VI	222.75 (287.31)	95.89 (94.38)	1.35 (0.33)

(Continued)

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Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of a (cm) for $M/A =$	0.5
													0.02	0.1
0206	San Fernando Earthquake, Hall of Records, San Bernardino	A	2-9-71	34°24'42" N 118°24'00" W	N 00° E	37.4	3.45	1.30	108.2	6.6	VI	53	30.77 (32.62)	6.96 (6.52) 0.24 (5.29)
0207	San Fernando Earthquake, San Bernardino Fairmont Reservoir, Fairmont	B	2-9-71	34°24'42" N 118°24'00" W	N 34° E	43.9	2.86	0.80	32.8	6.6	VI	53	15.95 (24.87)	4.09 (5.75) 0.21 (0.23)
0208	San Fernando Earthquake, University of California, Santa Barbara	I	2-9-71	34°24'42" N 118°24'00" W	N 42° E	64.6	3.84	1.23	16.40	6.6	V	62	53.21 (53.21)	16.01 (35.89) (0.41) (1.03)
0210	San Fernando Earthquake, Fire Station, Mount	A	2-9-71	34°24'42" N 118°24'00" W	S 45° E	17.00	1.69	1.45	34.40	6.6	V	52	24.72 (15.60)	4.49 (3.55) (0.49) (0.06)
0213	San Fernando Earthquake, 1215 Gajety, Hoover Dam	B	2-9-71	34°24'42" N 118°24'00" W	S 45° E	0.65	0.27	0.21	378.3	6.6	III	28	1.79 (2.23)	0.81 (0.60) (0.01) (0.007)
P214	San Fernando Earthquake, 4467 Sunset Boulevard, Los Angeles	I	2-9-71	34°24'42" N 118°24'00" W	S 01° E	154.00	21.20	8.07	36.2	6.6	VII	15	91.92 (140.85)	36.69 (27.92) 2.41 (0.59) (0.60)
P217	San Fernando Earthquake, 3345 Wilshire Boulevard, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	N 00° E	108.00	14.70	9.94	40.0	6.6	VII	35	125.85 (110.44)	37.81 (29.81) 0.68 (0.88)
P220	San Fernando Earthquake, 646 West 19th Street, Costa Mesa	I	2-9-71	34°24'42" N 118°24'00" W	N 00° E	88.10	16.10	9.09	95.8	6.6	VI	60	165.61 (138.30)	28.63 (37.10) 0.51 (0.20) (0.48)
P221	San Fernando Earthquake, Santa Anita Reservoir, Arcadia	B	2-9-71	34°24'42" N 118°24'00" W	N 00° E	137.00	5.29	3.15	43.3	6.6	VI	28	13.33 (13.87)	3.65 (2.71) (0.16) (0.08)
P222	San Fernando Earthquake, Navy Laboratory, Port Hueneme	A	2-9-71	34°24'42" N 118°24'00" W	S 00° E	25.20	5.51	4.92	79.3	6.6	VI	58	146.11 (282.46)	59.86 (62.50) 0.75 (0.37) (0.16)
P223	San Fernando Earthquake, Peddington Reservoir, San Dimas	B	2-9-71	34°24'42" N 118°24'00" W	N 35° E	69.70	4.60	2.07	65.0	6.6	V	32	21.28 (26.80)	4.64 (6.70) (0.17) (0.17)
P231	San Fernando Earthquake, 8441 Airport Boulevard, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	N 00° E	41.30	10.40	8.28	51.7	6.6	VI	30	160.46 (164.39)	77.68 (75.54) 0.46 (0.40)
Q233	San Fernando Earthquake, 14724 Ventura Boulevard, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	S 12° E	243.00	31.50	18.20	29.3	6.6	VII	36	274.98 (235.61)	57.98 (52.26) 1.42 (0.19) (0.32)
Q236	San Fernando Earthquake, 1140 North Orchid Avenue, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	South	167.00	9.65	3.42	34.9	6.6	VII	36	85.58 (67.73)	17.84 (13.87) 0.45 (0.21) (0.21)
Q239	San Fernando Earthquake, 1100 North Orchid Avenue, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	South	122.00	10.30	5.85	38.0	6.6	VII	36	134.23 (129.27)	33.81 (27.34) 1.31 (0.13) (0.13)
Q241	San Fernando Earthquake, 222 Figueroa Street, Los Angeles	I	2-9-71	34°24'42" N 118°24'00" W	N 37° E	86.80	17.90	9.22	41.8	6.6	VII	25	126.98 (131.34)	41.34 (49.45) 1.10 (0.06) (0.06)
B244	San Fernando Earthquake, 840 West First Street, Los Angeles	A or I	2-9-71	34°24'42" N 118°24'00" W	N 37° E	149.00	18.30	9.40	41.9	6.6	VII	20	132.22 (128.33)	30.06 (22.82) 1.05 (0.43) (0.43)
B246	San Fernando Earthquake, 8446 Sunset Boulevard, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	South	115.00	16.70	8.29	35.7	6.6	VII	23	103.06 (98.21)	29.58 (29.34) 0.77 (0.80) (1.42)
B248	San Fernando Earthquake, 6430 Sunset Boulevard, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	South	184.00	19.70	7.68	35.7	6.6	VII	28	102.71 (95.96)	26.78 (22.35) 0.75 (0.14) (0.59)

(Continued)

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Table A1 (Continued)

CIT File No.	Recording Station	Site Classifi- cation	Date of Earthquake	Epicenter Location	Instrument Component	A		B		Richter Magnitude M _b	Modified Mercalli Intensity	Duration sec	Values of μ (cm) for $M/A =$		
						Peak Acceleration cm/sec ²	Peak Velocity cm/sec	Peak Displace- ment cm	0.02				0.1	0.5	
R249	San Fernando Earthquake, 1900 Avenue of the Stars, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	N 44° E S 46° E Up	79.80 84.10 57.36	16.20 10.00 2.03	11.40 7.34 2.03	39.2	6.6	VII	20	(146.67) (112.36)	(39.13) (25.20)	(0.62) (0.48)
R251	San Fernando Earthquake, 234 South Figueroa Street, Los Angeles	A or I	2-9-71	34°24'42" N 118°24'00" W	N 37° E S 53° E Up	195.00 188.00 67.50	16.70 18.70 7.78	8.93 9.49 4.75	41.8	6.6	VII	20	(111.41) (74.96)	(33.32) (22.13)	(0.35) (1.20)
R253	San Fernando Earthquake, 533 South Fremont Avenue, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	N 30° W S 60° W Up	242.00 220.00 81.60	19.20 18.00 9.88	11.40 12.40 5.40	42.0	6.6	VII	25	(106.63) (119.14)	(21.02) (20.32)	(0.47) (0.35)
S255	San Fernando Earthquake, 6200 Wilshire Boulevard, Los Angeles	I	2-9-71	34°24'42" N 118°24'00" W	N 08° E S 82° W Up	123.00 128.00 46.80	22.50 21.90 5.20	15.80 10.90 2.65	38.9	6.6	VII	21	(181.92) (151.37)	(54.32) (36.72)	(1.07) (1.23)
S258	San Fernando Earthquake 3440 University Avenue, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	N 29° E S 61° E Up	83.30 86.30 54.50	17.20 18.50 7.14	10.30 10.50 3.56	44.6	6.6	VII	39	(180.76) (183.65)	(51.49) (58.34)	(1.31) (1.93)
S261	San Fernando Earthquake, 1177 Beverly Drive, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	N 59° E S 31° W Up	97.70 107.00 64.00	18.30 11.20 4.95	12.20 5.92 2.26	39.6	6.6	VII	39	(146.70) (55.80)	(41.47) (7.50)	(0.61) (0.25)
S262	San Fernando Earthquake, 5900 Wilshire Boulevard, Los Angeles	I	2-9-71	34°24'42" N 118°24'00" W	N 37° W S 53° W Up	68.30 93.60 32.90	25.70 27.80 6.17	16.50 13.70 2.74	39.0	6.6	VII	25	(208.88) (209.72)	(97.67) (74.31)	(2.90) (2.80)
S265	San Fernando Earthquake, 3411 Wilshire Boulevard, Los Angeles	I	2-9-71	34°24'42" N 118°24'00" W	N 08° E S 82° W Up	104.00 125.00 53.70	17.80 18.20 6.79	8.69 12.60 3.56	39.9	6.6	VII	21	(109.37) (138.85)	(26.50) (21.19)	(0.48) (0.13)
S266	San Fernando Earthquake, 3550 Wilshire Boulevard, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	N 08° E S 82° W Up	153.00 129.00 54.20	17.50 21.40 7.08	8.04 11.60 3.15	40.0	6.6	VII	30	(124.30) (188.50)	(28.02) (38.34)	(0.58) (0.60)
S267	San Fernando Earthquake, 3546 Century Boulevard, Los Angeles	A	2-9-71	34°24'42" N 118°24'00" W	N 08° E S 82° W Up	55.50 61.50 25.40	13.50 13.80 5.42	8.49 9.38 3.64	52.0	6.6	VI	49	(110.99) (144.92)	(32.18) (38.74)	(0.39) (0.30)
7286	El Centro, Imperial Valley Irrigation District	A	10-21-71	32°58'00" N 116°00'00" W	N 08° E S 82° W Up	58.40 46.50 25.40	6.22 6.05 5.42	4.24 3.33 0.78	46.5	6.5	VI	30	(75.32) (42.66)	(20.07) (10.23)	(0.17) (0.55)
7287	El Centro, Imperial Valley Irrigation District	A	1-23-51	32°59'00" N 115°44'00" W	N 08° E S 82° W Up	30.30 27.50 13.20	2.98 3.09 1.21	1.95 1.00 0.89	27.5	5.6	VI	30	(20.28) (15.94)	(4.95) (3.48)	(0.17) (0.26)
7288	El Centro, Imperial Valley Irrigation District	A	6-13-53	32°57'00" N 115°43'00" W	N 08° E S 82° W Up	7.21 35.80 16.80	1.39 6.32 0.88	1.31 1.51 0.78	23.6	5.5	V	30	(46.70) (135.00)	(7.69) (27.22)	(0.12) (0.35)
7289	El Centro, Imperial Valley Irrigation District	A	11-12-54	31°30'00" N 116°00'00" W	N 08° E S 82° W Up	24.10 27.00 4.74	3.76 3.17 0.95	0.99 2.66 1.09	149.8	6.3	IV	30	(16.07) (19.05)	(5.65) (6.58)	(0.31) (0.33)
7292	El Centro, Imperial Valley Irrigation District	A	12-16-55	33°00'00" N 115°30'00" W	N 08° E S 82° W Up	62.50 71.00 56.40	4.60 5.16 1.54	2.06 2.19 0.62	23.5	5.4	VI	30	(12.83) (14.51)	(1.76) (3.97)	(0.03) (0.28)
7293	El Centro, Imperial Valley Irrigation District	A	8-7-66	31°48'00" N 116°30'00" W	N 08° E S 82° W Up	13.50 14.70 4.96	2.43 2.40 1.36	2.02 1.66 1.72	148.1	6.3	VI	30	(20.07) (17.78)	(5.68) (5.83)	(0.36) (0.03)
0294	City Hall, Ferndale	I	7-6-34	41°42'00" N 124°36'00" W	N 45° W S 45° W Up	14.50 14.60 5.98	1.40 1.05 0.82	1.12 1.26 1.03	128.9	5.8	IV	12	(14.93) (11.15)	(4.69) (2.43)	(0.13) (0.06)
0295	Federal Building, Helena, Montana	HR	10-31-35	46°37'00" N 111°58'00" W	N 08° E S 82° W Up	29.30 25.20 7.11	0.54 0.39 0.32	0.32 0.16 0.67	5.8	5.0	VII	12	(0.09) (0.05)	(0.03) (0.01)	(0.0009) (0.003)
0297	Helena, Montana Federal Building	HR	11-28-35	46°37'00" N 111°58'00" W	N 08° E S 82° W Up	74.80 83.00 31.70	3.22 3.88 1.42	0.84 0.99 0.78	5.8	5.0	VI	21	(3.79) (6.38)	(1.03) (1.83)	(0.02) (0.04)

(Continued)

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Table A1 (Continued)

CIT File No.	Recording Station	Site Classifi- cation	Date of Earthquake	Epicenter Location	Instrument Component	Peak Acceleration cm/sec ²	V Peak Velocity cm/sec	D Displace- ment cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Values of u (cm) for M/A =		
												0.02	0.1	0.5
U298	City Hall, Ferndale	I	2-6-37	40°30'00" N 125°15'00" W	N 45° W S 45° W Up	38.40 35.90 13.90	4.07 2.71 1.59	0.90 0.99 1.04	85.1		V	(27.73) (21.40)	(6.21) (3.90)	(0.12) (0.06)
U299	Santa Barbara Courthouse	A	6-30-41	34°22' N 119°35' W	N 45° E S 45° E Up	233.00 172.00 68.50	21.70 21.60 3.64	3.74 3.92 2.59	35.9	5.9	VIII	17.58 (31.52) (62.93)	5.45 (5.86) (13.02)	0.84 (0.36) (1.22)
U300	City Hall, Ferndale	I	10-3-41	40°36' N 124°36' W	N 45° W S 45° W Up	118.00 113.00 37.50	6.92 5.74 2.51	2.95 2.51 1.12	29.8	6.4	VII	31.81 (33.23) (21.83)	8.11 (8.52) (5.68)	0.01 (0.21) (0.15)
U301	Public Library, Mollister	A	3-9-49	37°06' N 121°18' W	N 89° W S 01° W Up	193.00 119.00 69.50	11.70 8.26 3.63	1.40 1.71 0.96	28.3	5.3	VII	25.88 (34.25) (31.93)	4.96 (8.44) (12.21)	0.36 (0.64) (0.65)
U305	Public Library, Mollister	A	4-25-54	36°48' N 121°48' W	N 89° W S 01° W Up	52.00 48.90 23.10	4.19 4.52 1.94	2.24 1.36 1.06	36.2	5.3	VI	20.59 (19.73) (32.96)	6.04 (6.44) (11.15)	0.13 (0.11) (0.36)
U307	Public Library, Mollister	A	1-19-60	36°47' N 121°26' W	N 89° W S 01° W Up	55.50 35.30 23.60	5.25 3.64 2.10	1.85 1.21 1.08	8.5	5.0	VI	22.59 (19.56) (11.59)	6.60 (4.66) (3.49)	0.09 (0.19) (0.11)
U308	City Hall, Ferndale	I	6-5-60	40°49' N 124°53' W	N 46° W S 44° W Up	57.50 73.50 14.40	3.11 3.60 1.06	1.21 1.18 0.81	60.3	5.7	VI	21.45 (19.59) (47.65)	3.33 (2.71) (17.27)	0.18 (0.07) (0.015)
U309	Public Library, Mollister	A	4-8-61	36°30' N 121°18' W	N 89° W S 01° W Up	168.00 74.90 60.20	10.80 6.28 4.23	3.00 1.77 1.99	40.0	5.7	VII	26.38 (24.36) (54.70)	5.90 (4.86) (18.38)	0.01 (0.00) (0.50)
U310	Federal Office Building, Seattle, Washington	A	4-29-65	47°24' N 122°18' W	N 32° E S 58° E Up	52.10 77.50 32.10	5.59 9.35 8.35	2.55 5.43 1.62	22.3	6.5	VIII	58.54 (54.70) (46.18)	18.49 (18.38) (14.03)	0.50 (0.77) (0.68)
U311	Lincoln School Tunnel, Taft Field	A	6-27-66	35°57'18" N 120°29'54" W	N 21° E S 69° E Up	8.10 11.20 5.95	2.10 2.21 1.10	2.53 1.49 1.50	130.5	5.6	III	29.82 (26.16) (50.96)	7.98 (6.58) (8.38)	0.17 (0.09) (0.14)
U312	City Hall, Ferndale	I	12-10-67	40°30' N 124°36' W	N 46° W S 44° W Up	103.00 222.00 32.40	11.80 11.90 2.69	1.76 1.66 1.00	30.6	5.8	VI	14.16 (25.63) (40.65)	1.22 (4.88) (8.65)	0.00 (0.29) (0.12)
U313	Mollister	A	12-18-67	37°00'36" N 121°47'18" W	N 89° W S 01° W Up	13.10 16.20 10.00	2.67 1.74 1.14	2.26 2.03 1.33	39.0	5.2	V	22.10 (17.86) (60.40)	6.16 (4.89) (17.86)	0.14 (0.22) (0.22)
V314	Los Angeles Subway Terminal Substation	I, A	3-10-33	37°37' N 117°58' W	N 39° E S 51° W Up	62.30 95.60 63.60	17.30 23.60 9.07	8.21 16.30 5.72	54.9	6.3	VII	366.45 (206.09) (343.14)	109.52 (90.30) (50.87)	5.48 (0.99) (0.81)
V315	Public Utilities Building Long Beach	A	3-10-33	37°37' N 117°58' W	South West Up	182.00 155.00 279.00	29.40 16.50 30.10	22.70 11.80 26.30	27.2	6.3	VIII	205.28 (175.12) (82.90)	30.61 (50.87) (19.67)	0.63 (0.81) (1.00)
V316	Public Utilities Building, Long Beach	A	11-14-41	37°47' N 118°15' W	North East Up	39.70 53.60 8.47	7.61 9.32 1.04	2.47 3.56 0.56	6.2	5.4	VI	55.58 (68.87) (33.77)	14.26 (17.82) (8.02)	0.32 (1.87) (0.26)
V317	Los Angeles Chamber of Commerce Basement	A	11-14-41	37°47'00" N 118°15'00" W	S 50° E S 40° W Up	16.90 11.20 6.69	1.33 1.42 0.78	0.85 0.49 0.41	28.5	5.4	VI	60 (11.27) (13.61)	(2.73) (4.37) (0.11)	(0.07) (0.11) (0.11)
V319	City Recreation Building, San Luis Obispo	I	11-21-52	35°50' N 121°10' W	N 36° W S 54° W Up	52.90 2.40 26.30	3.35 2.48 2.63	0.80 1.26 1.20	76.1	6.0	VI	20.38 (19.51) (17.35)	5.19 (4.92) (4.18)	0.15 (0.10) (0.18)
V320	Southern Pacific Building San Francisco	A	3-22-57	37°40' N 122°28' W	N 45° E S 45° W Up	2.02 1.22 1.52	0.28 0.42 0.33	0.32 0.46 0.46	16.2	3.8	V			
V322	San Francisco, South Pacific Building	A	3-22-57	37°39'00" N 122°27'00" W	N 45° S S 45° W Up	8.56 24.00 6.05	0.83 2.41 0.88	0.40 1.11 0.88	17.3	4.4	V			

(Continued)

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Table A1 (Continued)

CIT File No.	Recording Station	Site Classi- fication	Date of Earthquake	Epicenter Location	Instrument Component	Peak Acceleration cm/sec ²	Peak Velocity cm/sec	Peak Displace- ment cm	Epicentral Distance km	Richter Magnitude M _s	Modified Mercalli Intensity V	Duration sec	Values of μ (cm) for M/A =			
													0.02	0.1	0.5	
V323	San Francisco, Alexander Building	I	3-22-57	37°39'00" N 122°27'00" W	N 81° E H 09° W Up	15.60 18.50 5.80	0.82 0.98 0.86	0.26 0.72 0.86	15.60	4.4	V					
V328	Southern Pacific Building Basement, San Francisco (Afterbuck)	A	3-22-57	37°39' N 122°29' W	N 45° E H 45° W Up	2.07 9.00 2.79	0.42 0.38 0.51	0.38 0.48 0.51	18.30	4.0	V	20	3.40	0.68	0.01	
V329	Port Merume	A	3-18-57	34°07'06" N 119°13'12" W	South East Up	163.00 86.80 24.70	17.90 8.85 1.93	4.02 2.61 0.48	5.4	4.7	V1	10 10 10		(13.56) (12.54)	(4.12) (1.35)	(0.80) (0.00)
V330	Federal Building, Eureka	I	9-4-62	40°58' N 124°12' W	N 79° E S 17° E Up	45.30 47.30 12.90	3.52 2.67 1.50	1.70 1.18 2.00	19.0	5.0	V1	70 70 70	11.07 (8.72) (7.52)	1.39 (1.64) (1.37)	0.09 (0.11) (0.17)	
V331	Old Ridge Route (CMT Site), Castro	I	7-15-65	34°29'06" N 118°31'18" W	South East Down	40.40 35.90 26.20	2.12 1.13 0.62	0.87 0.42 0.18	21.2	4.0	V	30(35) (35)	1.37 (11.52) (2.03)	0.36 (2.49) (0.49)	0.01 (0.03) (0.01)	
V332	Sacramento, Pacific Telephone and Telegraph	A	9-12-66	39°24'00" N 120°06'00" W	South East Up	14.40 12.40 8.07	1.57 1.74 0.83	0.74 0.75 0.65	151.5	6.3	V1					
V334	6074 Park Drive, Wrightwood	I	9-12-70	34°16'12" N 117°32'24" W	S 65° E S 25° W Down	139.00 194.00 53.00	8.87 9.63 3.18	2.21 1.03 1.44	13.4	5.4	V1	17 17 17	15.87 (20.88) (7.45)	3.82 (8.09) (2.77)	0.39 (0.31) (0.05)	
V335	Cedar Springs, Allen Ranch	NR	9-12-70	34°16'12" N 117°32'24" W	S 85° E S 05° W Down	69.80 54.90 59.30	5.55 1.96 2.56	2.42 2.00 1.15	20.8	5.4	V1	15 15 15	(3.39) (2.51) (0.83)	(1.58) (0.83)	(0.20) (0.06)	
V336	Cedar Springs, Pump House on dam abutment	I	9-12-70	34°16'12" N 117°32'24" W	S 54° E S 36° W Down	55.90 69.40 36.90	2.94 3.96 1.25	0.78 1.21 0.36	23.8	5.4	V1	10 10 10	(7.06) (8.81) (3.11)	(2.47) (3.11)	(0.29) (0.15)	
V338	Hall of Records, San Bernardino	A	9-12-70	34°16'12" N 117°32'24" W	North East Down	113.00 57.50 52.50	4.75 3.10 1.85	1.75 1.66 1.54	22.9	5.4	V1	25 25 30	8.42 (9.32) (12.21)	2.01 (2.49) (2.64)	0.18 (0.23) (0.23)	
V339	Southern California Edison Company, Colton	A	9-12-70	34°16'12" N 117°32'24" W	South East Up	40.20 35.30 33.60	2.55 1.87 1.30	0.95 0.70 0.72	31.5	5.4	V1	35(42) (42)	4.56 (8.94)	1.55 (1.53) (3.28)	0.06 (0.10) (0.21)	
V342	Millikan Library Basement, CIT, Pasadena	A	9-12-70	34°16'12" N 117°32'24" W	North East Down	19.30 18.70 12.30	1.53 1.44 0.68	0.76 0.52 0.52	56.0	5.4	V	24(23) (23)	8.42 (12.01) (5.00)	2.17 (2.41) (0.94)	0.05 (0.06) (0.008)	
V344	J. P. L. Basement, Pasadena	I	9-12-70	34°16'12" N 117°32'24" W	S 82° E S 06° W Down	14.40 24.10 15.40	1.03 2.00 1.86	1.03 2.37 1.44	58.9	5.4	V	16 24(16) (16)	(4.27) 4.86 (2.72)	0.53 (1.34) (0.41)	0.03 (0.03) (0.00)	
V370	Southern California Edison Company, Colton	A	4-8-68	33°11'24" N 116°07'42" W	South East Up	21.40 28.10 21.40	3.53 2.71 1.80	4.25 2.11 1.07	146.2	6.4	V1	81 85 85	26.49 (27.89) (20.56)	4.36 (5.12) (4.20)	0.05 (0.13) (0.08)	
V371	Engineering Building, Santa Ana, Orange County	A	4-8-68	33°11'24" N 116°07'42" W	S 04° E S 26° W Up	13.10 11.70 5.65	4.38 4.28 2.21	3.47 2.11 1.94	173.1	6.4	V	82(80) (80) (80)	89.77 (84.93) (57.14)	32.07 (29.72) (17.84)	0.17 (0.51) (0.25)	
V372	Terminal Island, Southern California Edison Plant, Long Beach	A	4-8-68	33°11'24" N 116°07'42" W	N 21° W S 69° W Up	8.73 9.51 5.14	3.19 2.86 1.75	4.98 2.11 -82	205.1	6.4	V1	52(50) (50)	40.33 (37.30) (35.52)	12.58 (12.35) (9.63)	0.65 (0.46) (0.02)	
V373	J. P. L. Basement, Pasadena	A, I	4-8-68	33°11'24" N 116°07'42" W	S 82° E S 06° W Down	7.35 7.02 4.89	1.35 1.32 0.99	0.53 0.96 0.72	220.3	6.4	V1	30(40) (40)	13.98 (14.95) (15.33)	4.04 (4.68) (3.54)	0.14 (0.18) (0.21)	
V375	Millikan Basement, CIT, Pasadena	A	4-8-68	33°11'24" N 116°07'42" W	North East Down	9.82 10.30 6.38	2.20 2.24 1.14	1.70 1.84 0.85	212.9	6.4	V1	52 52 52	21.97 (23.87) (8.03)	8.03 (1.45) (8.28)	0.20 (0.13) (0.27)	
V376	Pasadena, CIT Alhambra	A	4-8-68	33°11'24" N 116°07'42" W	South West Up	6.99 10.00 3.81	2.10 2.45 0.99	2.02 1.62 1.05	212.0	6.4	V1	60 60 60	(57.36) (30.07) (10.62)	(21.00) (10.62)	(0.57) (0.05)	

(Continued)

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Table A1 (Continued)

CIT File No.	Recording Station	Site Classifi- cation	Date of Earthquake	Epicenter Location	Instrument Component	A		D		Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for M/A =				
						Peak Acceleration cm/sec ²	Peak Velocity cm/sec	Peak Displacement cm	0.02					0.1	0.5			
Y377	Southern California Edison Building, Los Angeles	A	4-8-68	33°11'24" N 116°07'42" W	52° E 38° W Up	7.66 11.96 4.12	2.33 3.08 1.33	1.98 2.31 1.36			6.4	VI	44	(22.89) (36.74)	(9.63) (11.63)	(0.29) (0.58)		
Y378	Subway Terminal Basement, Los Angeles	A,1	4-8-68	33°11'24" N 116°07'42" W	52° E 38° W Up	6.97 11.40 5.41	2.23 3.07 1.23	1.07 2.30 1.01		218.8	6.4	VI	30(21) (21)	(29.18) (27.36)	(14.12) (9.75)	(0.90) (0.62)		
Y379	CMD Building, Vernon	A	4-8-68	33°11'24" N 116°07'42" W	83° E 07° W Up	18.60 18.50 6.97	4.27 4.65 2.38	2.50 2.69 1.47		212.2	6.4	VI	60(62) (62)	(119.20) (56.80)	(32.50) (14.84)	(0.19) (0.32)		
Y380	Hollywood Storage P. E. Lot, Los Angeles	A	4-8-68	33°11'24" N 116°07'42" W	South East Up	10.00 12.30 4.79	2.42 3.18 1.11	2.12 1.38 1.06		227.3	6.4	VI	51 51	(29.76) (55.24)	(10.96) (20.55)	(0.62) (0.73)		
	Oroville, California, Earth- quake, Oroville Dam	R	8-1-75	39°26'24" N 121°31'48" W	53° E 37° E Up	81.50 90.90 117.00	-5.00 4.50 -5.30	-1.60 1.30 -2.70		12.0	5.7	VIII	12 12	6.28 3.49	(13.06) (2.82)	2.11 0.73	(4.23) (0.84)	
	Nigata Earthquake, Prefecture Building, Abita, Japan	A	6-16-64	38°24'00" N 139°12'00" E	5° S 3° E V	135.40 137.97 45.87	12.69 17.33 4.56	2.95 2.91 4.65		120.0	7.5	VI*	38 38	23.79 15.55	(39.85) (31.02)	7.98 4.35	(11.01) (6.04)	
	Koyas Earthquake, Koyas Dam, India	R	12-10-67	17°22'12" N 73°42'00" E	7° E 1° E V	462.66 619.35 333.20	36.42 45.5 2.55	3.28 2.55		5.0	6.5	VIII	11 11	14.84 13.78	(17.10) (13.09)	4.01 4.48	(4.65) (3.11)	
	Gazli Earthquake, U.S.S.R.	A	5-17-76	40°36'00" N 63°24'00" E	5° S 5° E V	609.22 716.66 1327.45	9.06 12.45 69.65	27.31 50.99 54.47		10.0	7.3(M8) 6.5(M ₀)	IX	13.5 13.0 13.8	269.23 211.20	(237.77) (260.97)	63.78 64.66	(83.06) (74.89)	1.63 0.79
	Bucharest Earthquake, Romania	A	3-4-77	45°52'12" N 26°45'00" E	8° E 5° S Up	-174.54 201.75 107.05	5.35 2.69 12.50	10.60 20.06 -3.01		166.0	7.2	VIII	16.2 16.1 16.1	187.76 341.14	(185.93) (676.70)	63.40 123.03	(74.98) (170.57)	1.95 18.73
	Imperial Valley Earthquake Holtville Post Office	A	10-15-79		315° 225°	213.1 -246.2	-48.6 -44.7	-22.3 +25.3			6.6			317.57 283.73	(240.44) (242.36)	83.40 71.49	(58.65) (86.04)	1.88 0.43
	El Centro Array #10 Keystone Rd.	A	10-15-79		50° 320°	-168.2 -221.7	44.3 42.2	-27.1 16.7			6.6			284.87 273.03	(242.32) (202.26)	86.37 59.18	(66.83) (65.31)	3.89 1.17
	El Centro Array #3 Pine Union School	A	10-15-79		230° 140°	218.1 261.7	36.8 46.32				6.6			208.46 190.5	(165.07) (298.3)	38.98 58.5	(32.04) (65.3)	0.88 0.65

Table A2
Synthetic Earthquake Records

Simulated Earthquake Type	Approximate Magnitude	A		V Maximum Velocity cm/sec	D		AD V ²	V ² AD	Approximate Predominant Period sec	Total Duration sec	Values of u (cm) for N/A =				
		Maximum Acceleration cm/sec ²	Maximum Displacement cm		0.02	0.1					0.5				
CIT* A-1	8+	382.77	39.83	58.99	39.83	4.38	0.228	0.50	120	1501.85	(1570.95) [†]	453.64	(439.10) [†]	15.72	(8.09) [†]
A-2	8+	441.64	72.97	55.05	72.97	10.63	0.094	0.35	120	1409.44	(1409.44)	389.07	(391.81)	2.53	(5.55)
B-1	7	368.12	33.17	45.72	33.17	5.84	0.171	0.20	50	595.09		169.78		3.57	
B-2	7	308.70	22.22	48.26	22.22	2.94	0.339	0.22	50	492.66		159.19		5.13	
C-1	6	66.93	1.36	6.65	1.36	2.06	0.486	0.15	12	22.59		9.91		0.82	
C-2	6	57.23	0.88	6.09	0.88	1.36	0.736	0.20	12	26.89		9.91		0.46	
D-1	5	470.40	4.88	26.67	4.88	3.23	0.310	0.15	10	80.89		24.49		1.54	
D-2	5	490.00	6.84	28.94	6.84	4.00	0.245	0.15	10	74.69		17.60		0.59	
Seed-Idriss**	8-1/4	412.21	--	57.76	--	--	--	0.40	73	1256.10	(1269.86)	451.61	(424.90)	8.01	(11.65)
NRC		343.00		51.40						345.84		133.25		3.62	

* Jennings, Housner, and Tsai (1968).

** Seed and Idriss (1969).

† Values in parentheses are for reversed direction of shaking.

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